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MISSISSIPPI RIVER COMMISSION

INVESTIGATION OF SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

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Waterways Experiment Station
Vicksburg, Mississippi

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INVESTIGATION OF SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

PART I: INTRODUCTION

Authorization

1. The investigation was authorized by The President, The Engineer Board, in a letter dated 18 February 1946 to the Director, Waterways Experiment Station, subject, "Investigation of Oil and Gasoline Resistant Bituminous Pavements," Project Number MRS 457 and Work Order Number DAC 3109. Direction of the project was transferred to the Office, Chief of Engineers, by a letter dated 26 June 1946 from Office, Chief of Engineers, to The President, Mississippi River Commission, subject, "Funds for Investigational Program for Fiscal Year 1947." (Project 210 ESA 1947. Dir. Cons. 7A-24822 Mississippi River Commission).

Objectives

2. The objectives of this investigation were to determine the resistance of various types of bituminous pavements to the detrimental effects of the spillage of gasoline, kerosene, lubricating oil, and hydraulic brake fluid and to further determine which surfacing materials and methods of treatment would satisfactorily protect existing bituminous pavements from the detrimental effects of the spillage of these petroleum products. Specifically the pavements and materials were investigated to determine:

a. Their resistance to the detrimental action of water, gasoline, kerosene, lubricating oil, and hydraulic brake fluid.

b. Which materials, together with methods of treatment, were not adversely affected by water and were most satisfactory

for treating existing asphalt pavements to make them resistant to the action of the petroleum products mentioned above.

c. The most suitable temperatures, quantities, and other conditions for application.

d. Probable cost when applied to large areas.

e. Required curing period.

f. Resistance to abrasion.

Scope

3. The investigation was divided into two phases. The preliminary phase consisted of a laboratory study in which testing methods and procedures were devised and tests performed to select the most suitable products for further study. The second phase of the study was a small-scale field test to select the best of the materials passed by the laboratory tests.

Acknowledgments

4. The investigation was conducted by the Flexible Pavement Branch of the Soils Division of the Waterways Experiment Station for the ~~Airport~~ Airfields Branch of the Office, Chief of Engineers. Acknowledgment is made to the Engineer Research & Development Laboratories (formerly The Engineer Board) which accomplished the preliminary office study for the investigation. Appreciation is expressed to the producers of the various products listed in table 1 for their cooperation in furnishing information and materials.

PART II: LABORATORY TESTS

Solvents and Materials Tested

5. The solvents used in the laboratory tests were water, gasoline, kerosene, lubricating oil, and hydraulic brake fluid. Since little preliminary information was available on suitable materials which would resist the solvent action of petroleum products and meet the other service requirements for airfield pavements, numerous products were tested in order to find those that would best fulfill the behavior requirement. Most of the products investigated were manufactured primarily for other purposes; therefore, their behavior in these tests should in no way detract from their merit in applications for which they were intended. The materials tested fell into two general classifications; namely, bituminous pavements and surfacing materials. Bituminous pavement mixtures tested consisted of the following: asphaltic concrete with four grades of asphalt cement, penetration ranging from 45 to 150; asphaltic concrete using four different proportions of natural asphaltic limestone; asphaltic concrete with admixtures of powdered asphalt; and tar concrete made with four grades of tar. Protective surfacing materials tested were: four grades of tar; two types of vinylite resin; two bituminous emulsions with clay filler; six types of paints; and a synthetic rubber emulsion with admixed aggregate. The materials tested and the firms which supplied them are listed in table 1.

Preliminary Tests

6. Preliminary tests were conducted using 4-in. diameter by

2-1/2-in. compacted specimens to determine the proper procedure to be used in the laboratory phase of the study. The first preliminary tests consisted of submerging asphaltic concrete specimens in various solvents for different lengths of time and then determining the Marshall stability values. The Marshall stability value is the number of pounds required to crush a specimen at a temperature of 140° F in semi-confinement normal to the axis. The results of these tests are shown below as percentages of the original stabilities determined on similar specimens without subjecting them to the action of the solvents.

Reduction of Stability Due to Submersion in Solvents

Hours Submerged	Solvent	Per Cent of Original Stability
1/2	Gasoline	53
1	Gasoline	29
2	Kerosene	50
4	Kerosene	24
336	Lubricating Oil	62

It is seen in these tests that comparable reductions in stability required an excessively long soaking period for the lubricating oil solvent. This procedure was not adopted because the action of the solvents was not comparable to that existing in the field. In a second series of tests a wetting-draining cycle was used in which asphaltic concrete specimens were submerged in kerosene for 30 seconds and allowed to drain at room temperature for one hour. Marshall stability values were determined at the end of 0, 10, and 12 cycles. These data (not presented here) showed a progressive decrease in stability and specimen weight with increasing number of cycles in the solvent. Because of the favorable

trend shown in the second series of preliminary tests, further tests using the 30-seconds-submerging-and-one-hour-draining cycle were run in gasoline, kerosene, lubricating oil, and hydraulic brake fluid using asphaltic concrete specimens. Each specimen was weighed after each cycle. Stability tests were made on duplicate specimens at the end of 0, 7, 13, and 20 cycles except in the case of the lubricating oil where the final stability was determined after 22 cycles. The changes in weight and stability caused by the action of the solvents are shown as percentages of the original values in figures 1, 2, 3, and 4, plate 1.

Adopted Testing Procedures

7. Inspection of figures 1 and 2, plate 1, shows that at the end of 10 cycles appreciable losses in weight and stability had occurred when gasoline and kerosene were the solvents used. Inspection of figures 3 and 4, plate 1, shows that the losses were negligible at the end of 20 cycles when lubricating oil and hydraulic brake fluid were the solvents used. It appeared that 10 cycles were adequate to give reasonable results from gasoline and kerosene. The lubricating oil, as in the first preliminary tests, was very slow to act. The hydraulic brake fluid behaved similarly to the lubricating oil. In order to establish a reasonable period for the laboratory tests, 10 cycles of wetting and draining were adopted based on the results of tests using gasoline and kerosene. The following is the adopted testing procedure. Unit weights were determined for all specimens before beginning the cycles. The wetting-draining cycle consisted of submerging the specimens for 30 seconds in the solvent and then draining at room temperature for one hour. Specimens in quadruplicate

were submitted to 10 such cycles. Loss in weight was determined after each cycle, and after 10 cycles unit weights and Marshall stability values were determined. In stability determinations a water bath is usually used to heat the specimens to the testing temperature of 140° F. However, since in these tests water might have had a detrimental effect, the specimens were brought to the desired temperature by heating in an electric oven. To provide a basis for evaluating the test results, unit weight and stability values were also determined on four specimens from each mix without exposing them to the solvents. These specimens are identified as "control" throughout the report. If the pavement and coatings were resistant to the solvents, the weights and stability values of the specimens remained unchanged. If any were only partially resistant to the solvents, the degree of resistance was reflected by the loss of weight and stability.

Bituminous Pavements

Preparation and testing of specimens

8. Gradation of aggregate and bitumen content. The test specimens were made of asphaltic concrete in accordance with the directive which specified that asphaltic concrete would be prepared using (100-120) penetration asphalt binder and 1/2-in. maximum aggregate in accordance with tables 1 and 3 of Specification CE-65, "Flexible Pavements, Bituminous Binder and Wearing Courses (Central Hot Plant Mix)" dated 2 October 1942. Several gradations within the specifications were tried before one giving a satisfactory stability value was selected. This gradation is shown on plate 2. Tar concretes were also prepared using this gradation. The

only exception was that the asphaltic limestone was blended in accordance with the recommendation of the producer, as specified in the directive. The percentages of bitumen used in the preparation of test specimens were determined in accordance with procedures developed by the Waterways Experiment Station which utilize specimens prepared for the Marshall test, except in the case of the asphaltic limestone concrete where the recommendations of the producer were used. The percentages of bitumen used are shown in the following table:

Percentages of Asphalt Cement Used

Bituminous Pavements	Per Cent Bitumen Added
Asphaltic limestone concrete	
100% asphaltic limestone aggregate	5.5
80% asphaltic limestone - 20% sand	5.75
70% asphaltic limestone - 30% sand	5.75
50% asphaltic limestone - 50% sand	6.25
Asphaltic concrete with 4% Lincolnite (Admixture)	6.0
Asphaltic concrete with 2% Lincolnite (Admixture)	6.0
Asphaltic concrete (asphalt cement penetrations 45, 85-100, 100-120, and 120-150)	6.0
Tar concrete (grades RT-8, 9, 10, and 12)	7.0

9. Description of test specimens. The test specimens selected for the laboratory phase were of the standard size used for the Marshall stability test — 4 in. in diameter and 2-1/2 in. thick. They were compacted from the hot asphalt mixtures by 50 blows on each side of the specimens using a 12-1/2-lb hammer falling through a distance of 18 in. and striking a compaction foot 3-7/8-in. in diameter.

10. Testing of specimens. Specimens of bituminous pavements listed in the table above were tested in gasoline, kerosene, lubricating oil, and hydraulic brake fluid in accordance with the adopted testing procedure previously described. In order to obtain comparative values for

each type of pavement, unit weights and Marshall stability values were determined on control specimens which had not been subjected to the action of any solvent.

Test results

11. A summary of the average stability and flow values, unit weights, and void relations for the bituminous pavements before testing are given in table 2. The percentages of the original weights and the percentages of the original Marshall stability values after 10 cycles of wetting and draining are presented in table 3.

Discussion of test results

12. Effect of the various solvents. The solvents fell into two groups. The first comprised the fast-acting solvents which included kerosene and gasoline. The second group consisted of the slow-acting solvents which were lubricating oil and hydraulic brake fluid. Photographs 1 and 2 show typical examples of specimens tested in kerosene and lubricating oil.

13. Asphalt cements. The asphaltic concretes were all readily attacked by gasoline and kerosene while the action of lubricating oil and hydraulic brake fluid was less severe. Variations in grade of asphalt cement from 45 to 150 penetration made no appreciable difference in the resistance to leaching of the specimens by any solvent. The asphaltic concretes were attacked by the solvents more readily than any of the pavement mixtures tested.

14. Asphaltic limestone. The asphaltic limestone concretes were attacked by gasoline and kerosene, but were affected little by the brake

fluid and lubricating oil. The loss in stability and weight after 10 cycles of wetting and draining showed a tendency toward greater losses as the percentage of sand in the mixture increased; this trend was not consistent, however. It may be noted from table 2 that the specimens also decreased in original stability as the percentage of sand in the mixture increased. In general, all of the asphaltic limestone mixes withstood the action of kerosene and gasoline better than the straight asphalt cements.

15. Lincolnite. In general the specimens containing 6 per cent asphalt cement and an admixture of 4 per cent lincolnite were more resistant to the solvents than the ones containing 6 per cent asphalt cement and 2 per cent lincolnite. Both mixtures were attacked by gasoline and kerosene and were relatively unaffected by lubricating oil and brake fluid. The specimens containing the 2 per cent lincolnite were little better than the asphaltic concrete specimens without an admixture, whereas the 4 per cent specimens were slightly better than the asphaltic limestone admixtures.

16. Tar concrete. The tar concretes were relatively unaffected by any of the solvents. The original stability values for all grades of tar tested were low, but there was an increase in stability as the grade of the tars became more viscous. The stability values in general were lower after 10 cycles of wetting and draining. However, the very low values precluded any accurate appraisal of the tar concretes since considerable variation in the stability of individual specimens may be expected for materials with very low stability. Some of the specimens gained slightly in weight during testing which indicated absorption of

the solvent. There was no apparent leaching of the binder in any case as shown on photographs 1 and 2. The tar concretes had the most satisfactory behavior characteristics of any of the bituminous pavements tested.

Surfacing Materials

Preparation of specimens and test procedure

17. Several hundred 4-in. diameter by 2-in. high specimens used in testing the surfacing materials were prepared with 100-120 penetration asphalt cement and compacted in accordance with methods and procedures discussed in paragraphs 8 and 9.

18. Coating of specimens. The various surfacing materials were painted on the specimens except in the case of the Permakote, which was troweled on. These materials are listed in the succeeding paragraph. Specimens were coated in accordance with recommendations of the producers when such recommendations were made. Also, additional specimens were coated with 50 per cent more and 50 per cent less than the recommended amounts. Quantities used are shown in table 4. The specimens which appeared to have satisfactory coatings were selected by visual inspection and tested. Determinations were also made on the time of curing of the various surfacing materials; these are also shown on table 4. Photograph 3 shows a representative group of coated specimens before test. One surfacing material, the SYHM, checked and peeled while it dried, as shown in the upper part of photograph 4. In addition to the various thicknesses of coatings used, the SYHM was cured at several temperatures in an effort to eliminate the checking. In all

cases the material was unsatisfactory. It was apparent that this material offered no protection to the specimen so no specimens were tested.

19. Test procedure. Coated specimens were tested in quadruplicate (in accordance with the procedure outlined in paragraph 7) in the solvents as shown in the following tabulation:

Surfacing Materials and Solvents Tested

Surfacing Materials	Kerosene	Gasoline	Lubricating Oil	Hydraulic Brake Fluid	Water
Tar Seal RT-8, 9, 10, & 12	x	x	x	x	x
Jennite	x	x	x	x	x
Solac	x	x	x	x	x
Cordo 3M-219#1	x	x	x	x	x
Paints	x[1]	x	x	x	x
Permakote Surfacer	x	-	x	-	-
SYHM	-	-	-	-	x[2]

Notes: (1) If a paint failed in kerosene, no additional solvents were tested.
(2) Soluble in water.

For purposes of comparison, stability and flow values, unit weights, and void relations were also determined on coated specimens in quadruplicate without submitting them to the action of the solvents.

Abrasion tests

20. In the original plan of testing a laboratory abrasion test was included to reduce the number of surfacing materials in the field tests. The number of surfacing materials considered satisfactory for the field tests (as noted in subsequent paragraphs) was limited; therefore, the laboratory abrasion tests were not conducted.

Test results

21. The stability and flow values, unit weights, and void relations for the control specimens are given in table 2. The percentages of the original weights and the percentages of the original Marshall stability values of the test specimens after 10 cycles of wetting and draining in the various solvents are shown in table 3.

Discussion of test results

22. Visual observations made at the time of coating the specimens showed that the surfacing materials in general softened the specimens slightly when they were applied. The specimens regained their hardness as the surfacing materials cured. All materials tested were insoluble in water except the resin solution SYHM.

23. Jennite, Solac, and Cordo 3M-219#1. These surfacing materials were resistant to all solvents except kerosene. Although there were no losses in weight and no visible indication of leaching action by the kerosene (photograph 5), the specimens lost approximately 40 per cent of their original stability. It is noted that these materials were the only three subjected to wetting and draining in which the action of kerosene was more severe than that of gasoline; in general, on other materials the action of both solvents was about the same. The three coatings are considered satisfactory on the basis of the laboratory tests.

24. Permakote Surfacer. This material developed hair cracks while curing and sloughed off during the 10 cycles of wetting and draining in kerosene. There was some loss in weight and considerable loss in stability after the wetting and draining test. Specimens

coated with Permakote also showed considerable loss in stability when tested in lubricating oil. (See photographs 5 and 6.) The material was not subjected to the action of gasoline or brake fluid because of its poor behavior in the other solvents.

25. Tar seals. The various grades of tar were not attacked by and offered approximately the same degree of protection from all solvents. There were no changes in weights and no leaching action in any of the solvents as shown on photographs 5 and 6. Inspection of table 2 shows that the original stability values were very low. This may be explained by the fact that the tar coating softened in the oven at 140° F and penetrated the asphaltic concrete specimen, softening the outer edges. This in turn reduced the effective diameter of the specimen thereby giving a low stability value. Air bubbles developed on some of the tar coated samples. During testing to determine the effect of solvents some of the bubbles ruptured, thus exposing the surface of the asphaltic concrete. A hole leached out by gasoline in such an unprotected. area is shown in the lower part of photograph 4. The tar seals were considered satisfactory on the basis of laboratory tests.

26. Paints. All paint samples were subjected to 10 wetting-and-draining cycles in kerosene. Gleem Synthetic, Instant Dry White, A-120, manufactured by the Baltimore Paint and Color Works of Baltimore, Maryland was the only paint which offered adequate protection to the specimens. This paint was then subjected to 10 cycles of wetting and draining in the other solvents. All other paints cracked and peeled during testing so that, regardless of the weight and stability values shown in table 3, the leaching action of the solvent would soon have

destroyed the specimens. For the sake of brevity, the satisfactory paint will be referred to by the Waterways Experiment Station laboratory number which was No. 1189.

27. Limitations of the Marshall stability test. The Marshall stability test is known to be sensitive to the density and diameter of the specimens and to the temperature at which the specimens are tested. Slight variations in density occurred in the preparation of this large number of specimens in spite of the extreme care taken to guard against it. The diameters of the specimens were reduced when the solvents leached the binder and allowed the aggregates to slough off (as shown in photograph 1) or when the coating penetrated and softened the asphalt as in the case of the tar seal. The temperature control used on the oven for heating the specimens before determining the Marshall stability values varied about $\pm$ 2° F from the testing temperature of 140° F. Also to secure a fixed average eight specimens should be tested rather than four. The accumulation of these possible, even though small, errors may account for some of the erratic and inconsistent results obtained.

Summary

28. The evaluation of the laboratory testing indicated that tar concrete, asphaltic limestone concrete with 100 per cent asphaltic limestone aggregate, and asphaltic concrete with an admixture of 4 per cent lincolnite were the most suitable bituminous pavements of those tested. These were therefore selected for further study in the field. The most promising surfacing materials were Jennite, Solac, Cordo 3M-219#1, Paint 1189, and tar seal. Permakote Surfacer was also included in the

field study with the above-mentioned satisfactory surfacing materials because it was not certain that the laboratory test was a true indication of the character of the surfacing material due to the small size of the laboratory specimens. No abrasion tests were run as the number of materials found satisfactory by the laboratory tests was so small that all could be tested in the field.

PART III: FIELD TESTS

General

29. The laboratory tests indicated that kerosene was the most active solvent under the conditions imposed. It is also one of the principal ingredients of jet motor fuels. Therefore, kerosene was the only solvent used in the field phase, as lubricating oil and hydraulic brake fluid acted too slowly for the time allowed for the investigations. On the basis of the laboratory tests, the following materials were selected for field testing:

Bituminous Pavements	Surfacing Materials
Asphaltic concrete with 6% asphalt cement and 4 % lincolnite	Cordo 3M-219#1
Tar concrete with 8%* RT-10	Jennite
Asphaltic limestone concrete with 5.5% asphalt cement	Paint No. 1189
	Permakote Surfacer
	Solac
	Tar Seal

*Review of laboratory data indicated 8% tar to be more desirable than the 7% used in the laboratory phase.

30. The field tests, as conducted, using locked-wheel turns of a 15,000-lb wheel load to determine the effectiveness of the various pavements and surface treatments are believed to have provided a more severe test than such materials would normally receive in actual service. This is primarily due to the fact that traffic on service aprons consists of short radius turns or rolling traffic, which do not give the "scrubbing" action of a locked-wheel turn. In addition, the blocky tread on the tires of the testing equipment tended to gouge out the pavement more readily than a smoother tread airplane tire would have done. Thus, it

is entirely possible that some of the pavements which failed in these tests might prove satisfactory in service. It was noted in the field tests, however, that the kerosene had a lubricating effect and allowed the tire to slide over the test areas with some facility. This tended to reduce the effect of the rough tread to some extent. Since there was a difference in the behavior of the materials tested, it is believed that valid comparisons may be made even though the field tests may not have duplicated service conditions. The discussions on the action of the pavements, presented in succeeding paragraphs, should be evaluated with the foregoing considerations in mind.

Bituminous Pavements

Preparation of test areas

31. An asphaltic concrete of good quality and uniform texture which behaved satisfactorily under traffic was selected in the east turnaround of the asphalt test section as the site for the field tests. Areas of the pavement 4 ft square were removed and replaced by the pavements listed above. Photographs 11 and 12 show the pavements as placed. The pavement mixes were prepared in a pug mill mixer in the laboratory and transported to the field while still hot. The temperature of the tar concrete at the time of placing was 250° F while the other mixes were placed at 300° F. The mixes were placed by hand and rolled with 16 passes of an 8-ton tandem roller. Stability and flow values, unit weights, and per cent voids for cored samples of the in-place pavements are given in table 5.

Testing procedure

32. The test areas were saturated with kerosene at 9:00 a.m. and at 1:00 p.m. provided the pavement temperature was 100° F or more. The air and pavement temperature at time of testing are listed in table 6. One hour after saturation, a ninety degree turn of a locked wheel loaded with 15,000 lb was made by a Super "C" Tournapull. The field test consisted of 10 cycles of saturation and locked-wheel turns. Photograph 13 shows the Tournapull in testing position.

Data obtained

33. Visual observations of the condition of the pavements were made after each cycle of saturation and locked-wheel turns; these are summarized in table 6. Photographs of the test areas were made after 5 and 10 cycles of saturation and turning -- see photographs 16 through 19. After completion of 10 cycles of field testing, cores were obtained from each area subjected to saturation and turning. Stability and flow values, unit weights, and per cent voids for the cored samples are presented in table 5.

General behavior of pavements

34. In order to amplify the visual observations of pavement behavior (table 6), the following discussion is presented. In general, the first effect of kerosene saturation and locked-wheel turns was the softening of the pavement surface to depths of 1/32 to 1/4 in. Under the scrubbing action of the tires the soft surface material was scraped up into a scum of kerosene, asphalt, and fine aggregate. Continued cycles of saturation and turning gradually stripped the asphalt away from

the aggregate; this condition is shown as "strip" on table 6. Further saturation and scrubbing of the softened surface caused aggregate to tear loose from the pavement and created the condition designated as "scour". It is apparent that when a pavement started to scour such a condition could eventually lead to complete failure of the wearing surface.

Discussion of test results

35. Lincolnite. The admixture of 4 per cent lincolnite to an asphaltic concrete containing 6 per cent asphalt cement (penetration 116) improved its resistance very little. The kerosene softened the mix enough to form a scum on top during the first cycle. This condition persisted through the fifth cycle. In the sixth cycle, a few aggregates were loosened. Scour continued until 10 cycles of saturation and locked-wheel turns were completed (see photograph 18). The pavement is considered unsatisfactory even though it had high stability values before and after testing. It is considered that the high values were caused by the lincolnite hardening the asphalt cement.

36. Tar concrete. The tar concrete was made with 8 per cent RT-10. The pavement was rolled at a temperature that was slightly too high and caused roller cracks to develop. The pavement, however, was reasonably resistant to the action of the solvent and the locked-wheel turns. The equipment tire hit a patch near the edge of the test area on the first cycle and a slight amount of stripping resulted. Only a little softening and a slight amount of stripping had taken place at the end of the fifth cycle (photograph 16) and no scour could be detected.

The pavement was rigid enough after 10 cycles that the roller cracks could still be seen plainly (photograph 17) although a slight amount of shearing and tearing out of aggregate had started. The aggregate gradation for this mix was the same as shown on plate 2 and made a very low stability mix when tar was used as a binder. Reference to table 5 shows that the original in-place stability was only 102 lb and that no value could be obtained for pavement after testing. The pavement was too granular to be cored, yet it was the most satisfactory of any tested under these testing conditions. Results of laboratory tests on cores from bituminous test areas at MacDill Field, Florida, indicate that a high-stability tar concrete can be constructed. In view of this, the lack of stability in the tar concrete tested assumes minor importance since this may be compensated for by proper design.

37. Asphaltic limestone concrete. The asphaltic limestone concrete was the poorest of the bituminous pavements in behavior under field test conditions. The pavement softened and formed a scum during the first cycle. Aggregate began to tear loose in the fifth cycle. The softening and formation of the scum continued throughout the test. Larger aggregate tore out as the testing proceeded. Photographs 18 and 19 show the pavement at the end of the fifth cycle and tenth cycle, respectively. This pavement had high-stability values before and after testing. If it could be placed with less asphalt cement, the pavement would probably be more satisfactory. It can only be rated as very poor because of softening of the surface and excessive scouring.

38. Control. The control pavement was a section of the asphalt test section. This untreated test area was severely damaged by the

test. It softened and formed a surface scum during the first cycle. Stripping began in the third cycle and by the sixth cycle the asphalt had been stripped from the surface aggregate, and it was beginning to tear out. The disintegration continued progressively through the tenth cycle (photograph 19). There was a noticeable reduction in stability values for cores taken after 10 cycles of saturation and turning. The control pavement appeared to be slightly better than the asphaltic limestone but was still not satisfactory.

Surfacing Materials

Preparation of test areas

39. Weathering strips. In order to observe the effects of weathering on the various surfacing materials, strips of the six paints, Cordo 3M-219#1, Jennite, and Solac, 12 by 24 in. in size, were painted on the pavement in January 1947. A visual inspection of the weathering strips was made in October 1947. Paint 1189 had cracked around the edge of the strip at the junction of paint and asphalt; this cracking is believed due to temperature differentials caused by the light-reflecting qualities of the white paint and black asphalt. In addition, there were a few cracks in the interior of the strip and a slight chalking of the surface. The aluminum paint was in excellent condition and showed no cracks (it may be noted that aluminum paint did not protect the surface of laboratory test specimens from the solvent action). The other four paints were badly cracked and flakes of paint had spalled off. All showed chalking to a greater degree than Paint 1189. The Cordo 3M-219#1 showed some cracking of the underlying

asphalt. The surface had whitened and was opaque (the solution was originally clear). A small amount of spalling had taken place. The Jennite and Solac strips showed some pavement cracks which had penetrated through the surface treatments. Otherwise they were in good condition and did not appear to be promoting cracking of the underlying pavement.

40. Kerosene saturation test areas. The site selected for the field test in the east turnaround of the asphalt test section, mentioned in paragraph 30, was paved with a high-type asphaltic concrete consisting of 6 per cent asphalt cement and crushed limestone with gradation as shown on plate 1. This pavement was marked off into test areas 5 ft square. Photograph 7 is a general view of the area before the surfacing materials were placed. Four cores were drilled adjacent to each area for control values of unit weight and stability. The areas were coated with Jennite, Solac, Tar Seal, Cordo 3M-219#1, Paint 1189, and Permakote Surfacer. The materials were cured 6 days before testing started. Photographs 8, 9, 10, and 11 show the condition of the various areas before test.

Test procedure

41. The field tests consisted of 10 cycles of saturation and locked-wheel turns performed in the manner described in paragraph 32. Times of testing, together with air and pavement temperatures, are given in table 6.

Data obtained

42. Visual observations of the behavior of the surfacing materials and underlying pavement were made after each cycle of saturation

and turning. These are summarized in table 6. After 5 and 10 cycles, photographs of the various areas were made (photographs 20 through 25). After the completion of field testing, cores were taken in each area subjected to the saturation and turning cycles. Results of laboratory determinations of stability, flow, unit weight, and per cent voids for the cored samples are presented in table 5.

Discussion of field test results

43. In order to obtain a better understanding of the visual observations (table 6) and the discussion of behavior of each item in succeeding paragraphs, the following general description of the behavior of the pavement is presented. Saturation of the surfacing materials with kerosene and subjecting them to locked-wheel turns of the 15,000-lb wheel load first resulted in a wearing away of the treatment; this has been designated as treatment scour. Successive cycles of saturation and turning resulted in the complete removal of the surfacing in some areas, thus destroying its effectiveness as a protective medium. Following this condition, the kerosene had access to the underlying pavement and attacked the asphalt binder. Stripping of the asphalt from the pavement aggregate with the accompanying formation of scum then occurred. Continued cycles of saturation and turning gradually loosened the aggregates and scoured them from the pavement. The behavior of these test areas after the treatment had been scoured away was similar to that noticed for the bituminous pavement with no treatment.

44. Jennite. The coated area turned a dark green when saturated with kerosene for the first two cycles. The tops of the coarse aggregate began to show through the Jennite and the asphalt at the end of

the third cycle. This allowed the kerosene to dissolve the asphalt around the aggregate and form a thin layer of scum over the test area. Photograph 20 shows the scum and a few of the bare aggregate at the end of the fifth cycle. The stripping continued and the condition of the surface grew progressively worse until the end of the test. Photograph 21 shows that the Jennite had been completely scoured away and that the solvent was attacking the pavement. There was no scour of the underlying pavement. This material gave satisfactory protection while the coating was intact.

45. Solac. The behavior of Solac was similar to that of Jennite except that it apparently did not offer quite as much protection to the pavement. Discoloration in the first two cycles, stripping of coating in the third and loosening of aggregate in the sixth cycle characterized the behavior of Solac. Photograph 20 shows the scum which had formed at the end of the fifth cycle. Photograph 21 shows how much the aggregate had been scoured at the end of the tenth cycle. The protection was satisfactory as long as the coating was intact; however, it did permit some scour of the underlying pavement after 6 cycles of saturation and turning.

46. Tar seal. The tar seal was prepared with 0.25 gal of RT-10 tar per sq yd with enough sand to blot up all free tar. Though the surface was six days old when the testing began, it was not cured. The tire tracked in the first cycle. The sand-tar mix formed a lubricant in which the tire slid without damage to the pavement below. The pavement aggregate was beginning to strip in the eighth cycle and continued to strip slightly until the end of the test. Photographs 22 and 23 show

the test area after 5 and 10 cycles. The tar seal protected the pavement until it was displaced, and only slight stripping of the pavement was noted at the end of the field test.

47. Cordo 3M-219#1. This vinylite solution was painted on the surface. A slight scum was formed during the third cycle. The solution was clear so that it was very difficult to determine when the aggregate was scrubbed clean. Scouring of the treatment and slight stripping of pavement aggregate was noted in the third cycle. Photograph 22 shows the test area at the end of the fifth cycle with very little scum and no loose aggregate. The solvent attacked the unprotected pavement where the Cordo was scrubbed away, but the attack seemed slow. No scour of the pavement took place. Photograph 23 shows the test area after 10 cycles.

48. Paint 1189. This paint protected the asphalt satisfactorily throughout the 10 cycles. However, the kerosene-saturated surface was very slick and allowed the tire to skid easily. The only mark on the surface was a small gouged out place caused by a cut tread on the tire. The hole enlarged slightly by pavement scour, but was only 4 sq in. in area at the end of 10 cycles. Photographs 24 and 25 show the surface after 5 and 10 cycles. The discoloration shown on both photographs was tracked on by the wheels as no asphalt came through the painted surface.

49. Permakote Surfacer. This material shoved and scaled under the wheel during the first cycle so that no protection was given to the pavement below in succeeding cycles. Testing was discontinued after 5 cycles. Photograph 24 shows the area after 5 cycles of testing.

Photograph 25 shows the same area after being swept.

Control tests

50. In order to observe the effect of the twisting action of the 15,000-lb wheel load without any detrimental effects of the solvent, test areas were prepared on the same pavement with Jennite, Solac, Cordo 3M-219#1, tar seal, and Permakote Surfacer (photographs 14 and 15). The materials cured six days before field testing started. An area was left uncoated for comparison. Five locked-wheel turns were made on the dry surfaces of each test area by the Tournapull. The treatment and underlying pavement scoured badly in the sections coated with Jennite, Solac, Cordo, and there was a slight scour in the uncoated area. The tar seal and Permakote Surfacer sheared within themselves but there was no detrimental effect on the pavement below (photographs 26 and 27).

Summary of Field Tests

Bituminous pavements

51. The asphaltic concrete control pavement was scoured under the 10 cycles of saturation and testing in the field test. The asphaltic concrete containing 4 per cent lincolnite was only a little better than the asphaltic concrete without the admixture. The asphaltic limestone concrete softened excessively and was not satisfactory; its behavior was apparently worse than that of the asphaltic concrete. The tar concrete, though low in stability, was the most satisfactory type of pavement tested. Information from other tests, particularly those conducted at MacDill Field, Florida, indicates that it is

possible to design satisfactory tar concrete pavements of high stability. The pavements resisted abrasion in the following order: tar concrete, asphaltic concrete with lincolnite, asphaltic concrete control area, and asphaltic limestone concrete.

Surfacing materials

52. Jennite, Solac, Cordo 3M-219#1, Paint No. 1189, and tar seal protected the pavement from the action of kerosene while the coatings were intact. The Permakote Surfacer was unsatisfactory. Paint 1189 protected the pavement, except for one small hole, throughout the field tests. The tar seal was effective for 7 cycles of saturation and turning, and only slight stripping of the pavement took place thereafter. Cordo, Jennite, and Solac each protected the pavement for 3 cycles. At the end of 10 cycles there was stripping of the pavement under the Cordo and Jennite, and pavement scour under the Solac. In decreasing order of their effectiveness in the field tests, the surfacing materials are rated as follows: Paint No. 1189, tar seal, Cordo 3M-219#1, Jennite, Solac, and Permakote.

PART IV: CONSTRUCTION FEATURES AND COSTS

53. Material costs, quantities, application temperatures, methods of application, time of curing, and availability of the various products are listed in table 7.

Bituminous Pavements

54. The three bituminous pavements tested, lincolnite, tar, and asphaltic limestone, were all hot plant-mixed materials. Normal construction practice for this type of pavement will produce satisfactory results. Depending on proximity to sources of supply, in general the cost of the tar concrete will be less than that of the other two pavements tested.

Surfacing Materials

55. According to the manufacturers, Jennite may be applied by distributors if the material is diluted with water. However, constant circulation is necessary and great care must be taken to keep the material from clogging the nozzles on the spray bars. Pressure sprays may be used, but placement by squeege is recommended by the producer. The application may be divided into two coats to facilitate curing. Jennite has had wide use by the oil industry and some use by the Corps of Engineers on airfield installations. The service reports have been favorable. Solac was a product similar to Jennite and behaved in a comparable manner in the tests. Therefore, it may be inferred that the methods of application for Jennite described above would apply to Solac as well. No

knowledge of its use as a protection for airfield pavements is available. The Cordo 3M-219#1 can be placed by a spray or a squeege. This material can be diluted only with some diluent like ketones or mixtures of ketones and toluene. It is inflammable, both in the liquid and film states, and has a flash point of less than 80° F. Its record during the investigation was satisfactory, but no service records are available as the Cordo 3M-219#1 was especially made for this investigation. The tar may also be applied by distributors; a sand or aggregate cover should be used, and the seal properly cured before being opened to traffic. The paint may be sprayed or brushed on. In view of the slick surface presented by the paint, it would appear advisable to investigate the possibility of combining a fine cover aggregate or other non-skid surface with the paint. The Permakote Surfacer is troweled on. It is possible that a different proportion of ingredients than that used in the tests would provide a surface which does not crack when dry.

56. Based on costs of material alone and the quantities used in the tests, the materials in order of increasing cost were as follows: tar, Solac, Cordo 3M-219#1, Jennite, paint, and Permakote Surfacer. Tar was by far the cheapest of the materials tested, and it is doubtful that inclusion of cost of placing would change the relative cost of the surfacing materials except in unusual cases.

PART V: EVALUATION

57. The final selection of the most satisfactory bituminous pavements and surfacing materials for protection against the solvent action of petroleum products depends not only on their behavior in the laboratory and field tests but on cost, ease of construction, and other features. The following discussion presents an evaluation of the materials used in the test based on the foregoing considerations.

Bituminous Pavements

58. The asphaltic limestone concrete and lincolnite admixture to asphaltic concrete were not successful in preventing solvent action of petroleum products. The tar concrete performed satisfactorily although it had low stability. Since information from MacDill Field, Florida, indicates that tar concretes with high stability can be constructed, the low stability of the mix used in the test is of minor importance. In addition, tar concrete has the advantage of low cost. Therefore, tar concrete is considered the most satisfactory of the bituminous pavements tested and its use for protection against the solvent action of petroleum products is recommended.

Surfacing Materials

59. The Permakote did not perform satisfactorily in the laboratory or field tests; therefore, it is considered not suitable for protecting pavements from solvent action of petroleum products. Paint No. 1189 gave the best protection to the pavement but had the disadvantage

of being slippery when soaked with kerosene. This disadvantage could possibly be overcome by incorporating a fine cover aggregate. The paint was also relatively expensive. The tar seal was reasonably effective in protecting the pavement during the field tests. It is believed that good construction, using a cover aggregate, and proper curing would result in an effective surface treatment. No special problems would be encountered in placing the tar seal. It was the cheapest of the surfacing materials tested. The Cordo 3M-219#1 was almost as effective as the tar seal in protecting the pavement. However, it is inflammable in the liquid and dry states, which would preclude its use in installations where it would be subjected to jet plane exhaust or otherwise exposed to flame. It is relatively expensive, and can be diluted only by special liquids. Jennite and Solac both protected the pavement for the same length of time in the field tests, and appear to be comparable materials although subsequent behavior of the pavement was better under the Jennite. Solac is quoted as being less expensive than Jennite. No service data are available on Solac, but Jennite has had wide use as a protective cover against petroleum solvents. Based on all the foregoing considerations, the Permakote Surfacer and Cordo 3M-219#1 are considered unsatisfactory, Solac is probably satisfactory, Paint No. 1189 is satisfactory provided a cover aggregate can be used, Jennite is satisfactory, and tar seal the most satisfactory of the surfacing materials tested.

PART VI: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

60. Bituminous pavements can be protected from the detrimental effects of the spillage of gasoline, kerosene, lubricating oil and hydraulic brake fluid either at the time of construction by using suitable admixtures or as a temporary expedient by protective treatments applied subsequent to construction.

Bituminous pavements

61. ~~Tar~~ Bituminous concrete using coal tar is considered to be the most satisfactory bituminous pavement tested.

Surface Treatments
~~Surfacing materials~~

62. Based on the results of these tests, a coal tar seal with suitable cover aggregate is considered to be the most satisfactory surface ~~surfacing~~ treatment ~~material~~. Jennite and Solac are also considered satisfactory but are more expensive than tar.

Recommendations

63. On the basis of this study, the following recommendations for further study are made. This investigation has indicated that bituminous pavements can be protected from the detrimental effects of the spillage of petroleum products. It is therefore recommended that the investigation be continued to include other bituminous pavement types and surfacing materials. The laboratory method of testing is believed satisfactory.

It should be used to test additional materials as they become available and small-scale field tests conducted only when the laboratory tests have indicated a satisfactory product. The field testing methods should receive further study in order to make them more comparable to actual conditions. It is further recommended that materials and pavements proved satisfactory by the small field test at the Waterways Experiment Station be incorporated into field service tests at some active installation.

64. Pending results of further tests, it is recommended that existing asphaltic concretes be protected with a tar seal and that tar concrete or a tar seal be used for new construction in areas subject to solvent action.

TABLE 1

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Producers and Classification of Materials Tested

Trade Name	Type of Product	Producer
Asphalt Cement - Penetrations 45, 85-100, 100-120, & 120-150	Asphalt Cement	Standard Oil Co., Baton Rouge, La.
Asphaltic Limestone	Limestone naturally impregnated with asphalt	Alabama Asphaltic Limestone Co., Birmingham, Alabama
Lincolnite	Powdered Asphalt	The Ohio Oil Co., Findlay, Ohio.
Tar RT-8,9,10,12	Coal Tar	Koppers Co., Pittsburg, Pa.
Cordo 3M-219#1	Vinylite Resin	Cordo Chemical Corp., Norwalk, Conn.
Bakelite Resin SYHM	Ammonium salt of vinylite resin SYHM	Bakelite Corp., New York, N. Y.
Jennite	Clay type pitch emulsion	Maintenance Inc., Wooster, Ohio.
Solac	Similar to Jennite	Thomas Robinson Co., New York, N. Y.
A-120, Cleem Synthetic Instant Dry, White (WES Lab. No. 1189)	Paint	Baltimore Paint and Color Works, Baltimore, Md.
A-150, Tylon Heavy Duty Traffic Paint, White (WES Lab. No. 1190)	Paint	Baltimore Paint and Color Works, Baltimore, Md.
A-182, Traffic Paint, White (WES Lab. No. 1191)	Paint	Baltimore Paint and Color Works, Baltimore, Md.
11-1, Traffic and Zone, Marking Paint (WES Lab. No. 1192)	Paint	Pittsburgh Paint and Glass Co., Pittsburg, Pa.
3300, Luster Spread, White (WES Lab. No. 1193)	Paint	Glidden Paint Co., Cleveland, Ohio.
Aluminum, No. 15 (WES Lab. No. 1211)	Paint	The Sherwin Williams Co., Cleveland, Ohio.
Permakote Surfacer	A binder composed of a water emulsion of a neoprene compound and a premixed aggregate.	The Flintkote Co., New York, N. Y.

TABLE 2

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Summary of Test Properties

Material	Asphalt Cement Percent	Stability Lbs	Flow Value 1/100-Inch	Unit Weight Lbs per cu ft. Total Mix	Unit Weight Lbs per cu ft. Aggregate Only	Voids Percent Total Mix	Voids Percent Aggregate Only	Total Voids Filled With Asphalt Cement Percent
BITUMINOUS PAVEMENTS								
Asphalt - 45 pen.	6.0	986	22	142.3	133.8	6.2	19.4	68
85 - 100 pen.	6.0	730	19	142.0	133.5	6.3	19.6	68
100 - 120 pen.	6.0	814	19	141.6	133.1	6.5	19.8	67
120 - 150 pen.	6.0	578	19	143.6	135.0	5.1	18.6	73
100% Asphaltic Limestone	5.5	2786	31	141.3	133.5	2.1	14.2	85
80% Asphaltic Limestone 20% Sand	5.75	1857	24	138.1	130.2	4.9	17.3	72
70% Asphaltic Limestone 30% Sand	5.75	1408	22	140.5	132.4	3.7	16.3	77
50% Asphaltic Limestone 50% Sand	6.25	474	18	133.4	125.1	8.9	21.9	59
Tars - RT - 8	7.0	58	16	142.1	132.2	6.7	19.8	66
RT - 9	7.0	84	16	142.8	132.8	7.3	20.3	64
RT -10	7.0	125	15	143.1	133.1	6.9	20.0	66
RT -12	7.0	268	19	144.0	133.9	6.3	19.3	67
2% Lincolnite 6% Asphalt Cement	6.0	1237	21	138.7	127.6	5.8	23.2	75
4% Lincolnite 6% Asphalt Cement	6.0	2366	28	139.2	125.3	2.7	24.5	89
SURFACING MATERIALS (1)								
Uncoated Asphaltic Concrete	6.0	814	19	141.6	133.1	6.5	19.8	67
Coated with:								
Jennite		779	14	141.1	132.6	7.8	21.1	63
Solac		875	14	141.0	132.5	6.9	20.2	66
Cordo 3M - 219:1		861	12	141.6	133.1	6.5	19.8	67
Paint - 1189		800	12	141.6	133.1	6.5	19.8	67
Tars - RT - 8		564	14	140.5	132.1	7.2	20.4	65
RT - 9		540	13	141.0	132.5	6.9	20.2	66
RT -10		490	16	140.3	131.9	7.3	20.5	64
RT -12		420	14	140.5	132.1	7.2	20.4	65

NOTES:
(1) Specimens for testing the surfacing materials were made from asphaltic concrete using 100-120 penetration asphalt cement.

TABLE 3

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Summary of Results of Test After 10 Cycles

Material	Gasoline		Kerosene		Lubricating Oil		Brake Fluid		Water	
	Percent Original Weight	Percent Original Stability	Percent Original Weight	Percent Original Stability	Percent Original Weight	Percent Original Stability	Percent Original Weight	Percent Original Stability	Percent Original Weight	Percent Original Stability
BITUMINOUS PAVEMENTS										
Asphalt - 45 pen.	89	57	79	28	100	81	100	76		
85 - 100 pen.	86	44	84	38	100	104	100	86		
100 - 120 pen.	90	31	83	20	100	89	100	82		
120 - 150 pen.	88	53	85	47	100	77	100	74		
100% Asphaltic Limestone	95	56	94	58	100	118	100	99		
(80% Asphaltic Limestone (20% Sand	95	58	93	81	100	100	100	89		
(70% Asphaltic Limestone (30% Sand	94	70	88	44	101	111	100	75		
(50% Asphaltic Limestone (50% Sand	93	56	82	43	101	93	100	101		
Tars - RT - 8	100	90	101	102	100	119	100	66		
RT - 9	100	57	99	49	101	61	100	51		
RT -10	100	40	101	46	100	94	100	48		
RT -12	100	59	101	36	100	41	100	35		
(2% Lincolnite (6% Asphalt Cement	89	54	90	46	100	112	100	98		
(4% Lincolnite (6% Asphalt Cement	93	65	99	79	100	68	100	138		
SURFACING MATERIALS										
Asphalt - 100-120 pen.									100	100
Jennite	100	94	98	61	100	96	100	72	100	97
Solac	100	93	100	60	100	83	100	65	100	103
Cordo 3M-219#1	100	88	100	62	100	97	100	72	100	106
Permakote Surfacer			85	34	101	47				
Paints - 1189	100	66	100	98	100	79	101	66	100	99
1190			99	55						
1191			92	29						
1192			96	47						
1193			100	75						
1211			99	65						
Tars - RT-8	100	84	100	102	100	87	100	86	100	100
RT-9	100	80	100	75	100	94	100	96	100	101
RT-10	99	81	100	93	100	91	100	101	100	91
RT-12	100	88	100	104	100	107	100	105	100	104

TABLE 4

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Quantities of Surfacing Materials Used in Laboratory Tests

Product	Quantity Recommended	Quantities Used			Quantity Selected	Time of Curing
		1st Test	2nd Test	3rd Test		
Cordo 3M-219#1	None	0.04 gals/sq yd	0.08 gals/sq yd	0.12 gals/sq yd	0.08 gals/sq yd	24 hours
Jennite	0.14 - 0.18 gals/sq yd	0.08 gals/sq yd	0.16 gals/sq yd	0.24 gals/sq yd	0.16 gals/sq yd	48 hours
Paints	None	(1) 0.11 gals/sq yd	0.17 gals/sq yd	—	0.11 gals/sq yd	24 hours
Permakote Surfacer	1/8-in. thickness	(2) 1/8-in. thickness	—	—	1/8-in. thickness	72 hours
Solac	0.14 - 0.18 gals/sq yd	0.08 gals/sq yd	0.16 gals/sq yd	0.24 gals/sq yd	0.16 gals/sq yd	48 hours
SYHM	0.02 gals/sq yd	0.008 gals/sq yd	0.017 gals/sq yd	(3) 0.08 gals/sq yd	0.08 gals/sq yd	24 hours
Tar RT 8 and 9	0.2 - 0.3 gals/sq yd	0.10 gals/sq yd	0.20 gals/sq yd	0.30 gals/sq yd	(4) 0.10 gals/sq yd	24 hours
Tar RT 10 and 12	0.2 - 0.3 gals/sq yd	0.10 gals/sq yd	0.20 gals/sq yd	0.30 gals/sq yd	(4) 0.13 gals/sq yd	24 hours

NOTES:
(1) This amount required for complete coverage of specimen.
(2) Limited supply, only one thickness tried.
(3) This amount required to give coverage.
(4) Tar applied as a paint without aggregates so amount used is small.

TABLE 5

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Summary of Field Test Results

				Before Testing				After Testing			
			Asphalt Cement Percent	Marshall Stability Pounds	Flow Value 1/100-Inch	Total Mix Unit Weight Lbs/Cu Ft	Total Mix Voids Percent	Marshall Stability Pounds	Flow Value 1/100-Inch	Total Mix Unit Weight Lbs/Cu Ft	Total Mix Voids Percent
Material	Type	Amount Used									
KEROSENE SATURATED SURFACES											
Jennite	Surfacing Material	0.16 gals. per sq yd	6.0	724	23	150.2	3.1	570	22	148.4	4.2
Solac	Surfacing Material	0.16 gals. per sq yd	6.0	664	21	148.2	4.3	690	22	148.8	3.9
Cordo 3M-219#1	Surfacing Material	Coverage	6.0	874	24	148.0	4.5	635	26	148.9	3.9
Permakote Surfacer	Surfacing Material	1/8-inch coverage	6.0	823	21	148.9	3.9	639	22	149.2	3.7
Tar Seal RT-10	Surfacing Material	0.25 gals. per sq yd	6.0	729	23	149.7	3.4	803	26	148.9	3.9
Paint #1189	Surfacing Material	Coverage	6.0	853	21	150.0	3.2	782	22	149.6	3.4
Control	Bituminous Pavement	-	6.0	916	23	150.1	3.1	601	19	148.3	4.3
Asphaltic Limestone	Bituminous Pavement	100%	5.5	2295	35	138.5	4.0	2584	39	142.8	1.0
Tar Concrete RT-10	Bituminous Pavement	8%	-	102	22	139.3	8.2	-	-	142.3	6.2
Lincolnite	Bituminous Pavement (Admixture)	4%	6.0	2850	31	137.7	2.4	3101	34	138.4	3.3
DRY CONTROL SURFACE											
Jennite								786	20	148.8	3.9
Solac								428	26	145.5	6.1
Cordo 3M-219#1								647	20	148.9	3.9
Permakote Surfacer								756	27	149.3	3.7
Tar Seal RT-9								557	28	148.2	4.3
Control								741	20	149.5	3.5

TABLE 6

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Observations During Field Testing

Cycle	Date	Time	Temperature Degrees F Air	Temperature Degrees F Pavement	Bituminous Pavements: Lincolnite	Bituminous Pavements: Tar Concrete	Bituminous Pavements: Asphaltic Limestone	Bituminous Pavements: Control	Surfacing Materials: Jennite	Surfacing Materials: Solac	Surfacing Materials: Tar Seal	Surfacing Materials: Cordo	Surfacing Materials: Paint 1169	Surfacing Materials: Permakote
					Summary of Visual Observations(1)									
KEROSENE SATURATED SURFACES														
1	29 April	10 AM	88	103	Soft	Tire hit patch Slight strip	Soft	Soft	Discolored	Discolored	Treatment scour	No effect	No effect	Treatment scour
2	29 April	2 PM	90	101	Soft	Slight strip	Soft	Soft	Discolored	Discolored	Treatment scour	No effect	No effect	Entire treatment scoured
3	30 April	2 PM	90	100	Soft	Slight strip	Soft	Strip	Treatment scour Pavement slight strip	Treatment scour Pavement slight strip	Treatment scour	Treatment scour Pavement slight strip	No effect	Entire treatment scoured
4	1 May	10 AM	88	112	Soft	Slight strip	Soft	Strip	Pavement slight strip	Pavement slight strip	Treatment scour	Pavement slight strip	No effect	Entire treatment scoured
5	1 May	2 PM	90	116	Soft	Slightly soft	Slight scour	Strip	Pavement slight strip	Pavement slight strip	Treatment scour	Pavement slight strip	Small hole made by tire defect	Failed
6	2 May	11 AM	80	120	Slight scour	Slightly soft	Scour	Slight scour	Pavement slight strip	Pavement slight scour	Treatment scour	Pavement slight strip	Pavement slight scour in hole	No test
7	2 May	2 PM	83	118	Slight scour	Slight strip	Scour	Slight scour	Pavement slight strip	Pavement slight scour	Treatment scour	Pavement slight strip	Pavement slight scour in hole	No test
8	3 May	10 AM	81	112	Scour	Strip	Scour	Scour	Pavement slight strip	Pavement scour	Pavement slight strip	Pavement slight strip	Pavement slight scour in hole	No test
9	3 May	2 PM	85	124	Scour	Strip	Scour	Scour	Pavement slight strip	Pavement scour	Pavement slight strip	Pavement slight strip	Pavement slight scour in hole	No test
10	5 May	10 AM	83	102	Scour	Slight scour	Bad scour	Scour	Pavement strip	Pavement scour	Pavement slight strip	Pavement slight strip	Pavement slight scour in hole (4 sq. in. area)	No test
DRY CONTROL SURFACES														
-	12 May	1 PM	90	122	No test	No test	No test	Slight scour	Treatment scour Pavement scour	Treatment scour Pavement scour	Treatment scour	Treatment scour Pavement scour	No test	Treatment scour

NOTE:

1. Definitions of terms used in the tabulation are as follows:

Bituminous Pavements

Soft - Softening of pavement surface, generally accompanied by formation of scum of asphalt, kerosene, and fine aggregate.
Strip - Stripping of asphalt from the aggregate, usually preceded by softening and scum.
Scour - Removal of aggregate from the pavement under scrubbing action of lock wheel turn.

Surfacing Materials

Discolored - Dark green surface color seen after application of kerosene.
Treatment scour - Gradual removal of surfacing by scrubbing action of locked wheel turn.
Pavement strip - Stripping of asphalt from pavement aggregate after surfacing is scoured away; usually accompanied by scum.
Pavement scour - Removal of aggregate from pavement after treatment has been scoured away.

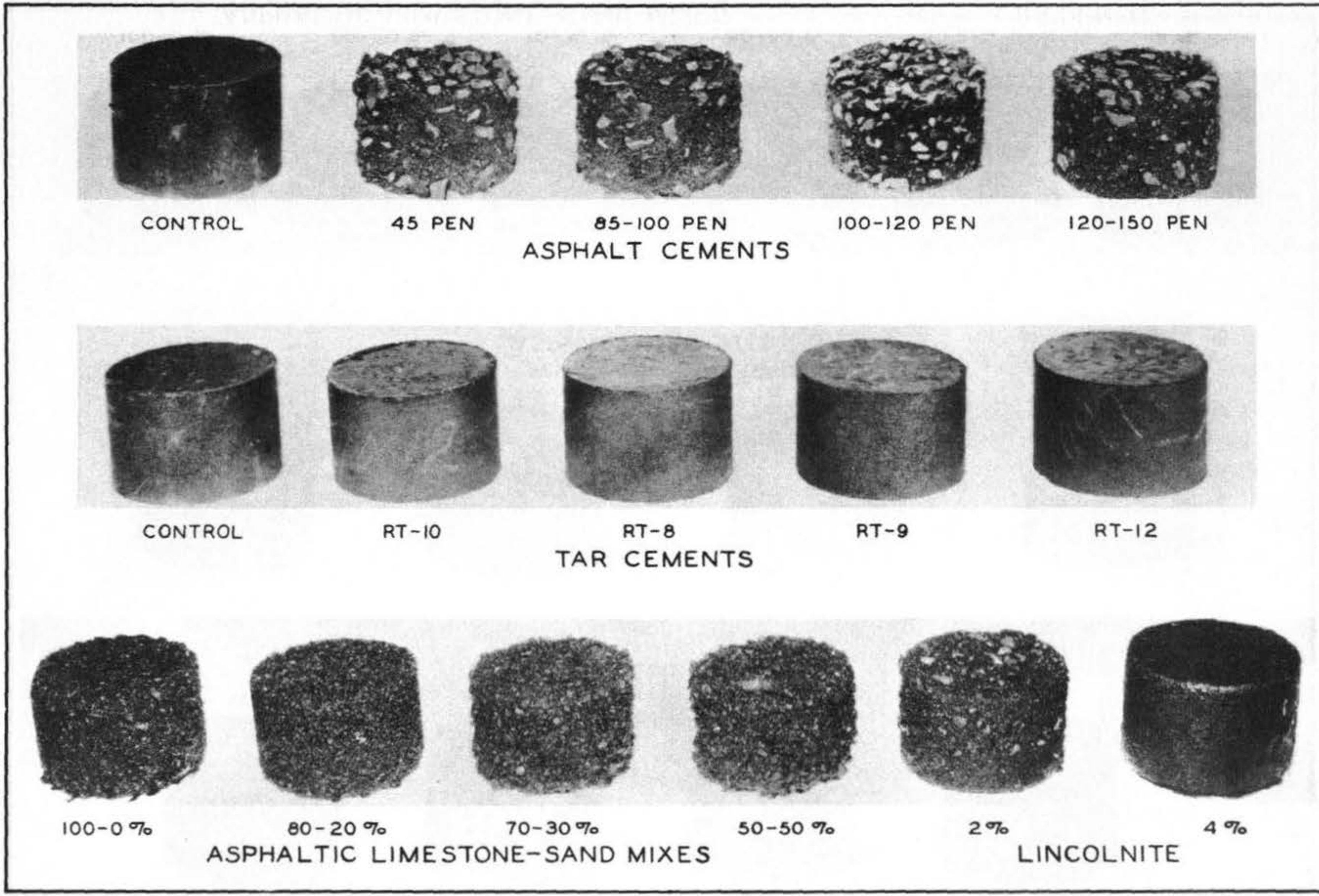
TABLE 7

SOLVENT RESISTANT TREATMENTS FOR BITUMINOUS PAVEMENTS

Summary of General Information

Product	~~Protection~~	Material Cost fob plant (1)	Quantity Used	Application Temperature Degrees F.	Methods of Application	Time of Curing	Availability
			BITUMINOUS PAVEMENT				
Lincolnite	~~Unsatisfactory~~	1¢ lb.	4%	250-300	Admixture	Soon as rolled	Limited
Tar	~~Poor~~	10¢ gal.	8%	175-250	Hot Plant	Soon as rolled	Large supplies
Asphaltic Limestone	~~Very poor~~	$4.00 ton.	100%	250-300	Hot Plant	Soon as rolled	Limited
			SURFACING MATERIALS				
Jennite	~~Fair~~	90¢ gal.	0.15 gal. per sq yd	+45	Distributor Brush Squeege Spray	48 hours(2)	Large supplies
Solac	~~Fair~~	45¢ gal.	0.15 gal. per sq yd	+45	Distributor Brush Squeege Spray	48 hours(2)	Limited
Cordo 3M-219#1	~~Fair~~	$1.80 gal.	0.05 gal. per sq yd	60-100	Spray Squeege	24 hours	Limited
Tar	~~Fair~~	10¢ gal.	0.25 gal. per sq yd	150-225	Distributor	Soon as rolled	Large supplies
Paint 1189	~~Excellent~~	$2.35 gal.	0.1 gal. per sq yd	+32	Spray Brush	24 hours	Limited
Permakote Surfacer	~~Unsatisfactory~~	44¢ sq yd	1/8-inch Thickness	+32	Trowel	72 hours	Limited

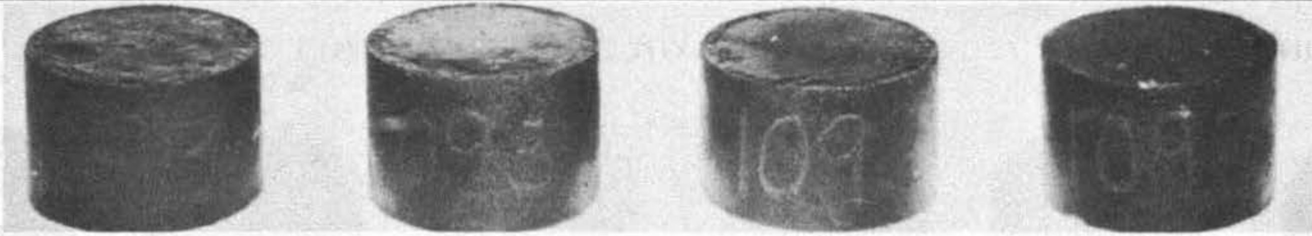
NOTES:
(1) Cost based on 1946 prices.
(2) Cures in 48 hours so that rubber tired traffic may use it.



PHOTOGRAPH 1

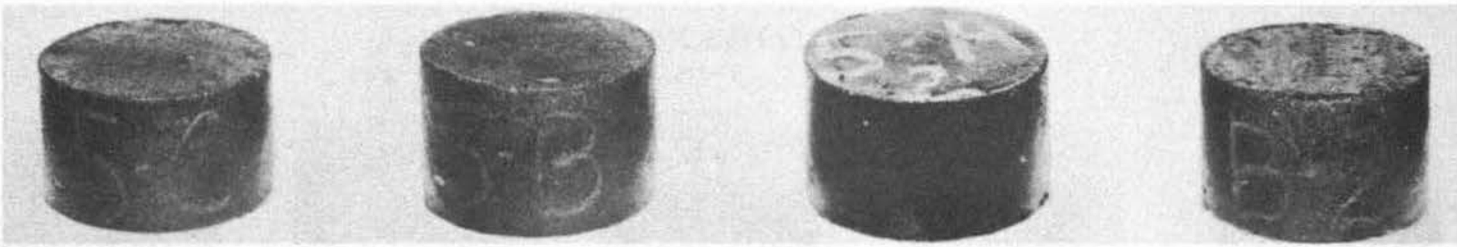
BITUMINOUS PAVEMENTS AFTER 10 CYCLES IN KEROSENE

PHOTOGRAPH 2



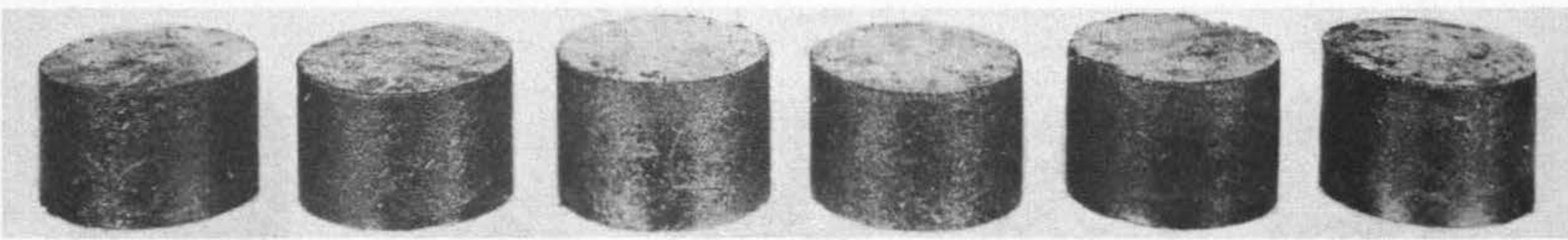
RT-8 RT-9 RT-10 RT-12

TAR CEMENTS



45 PEN 85-100 PEN 100-120 PEN 120-150 PEN

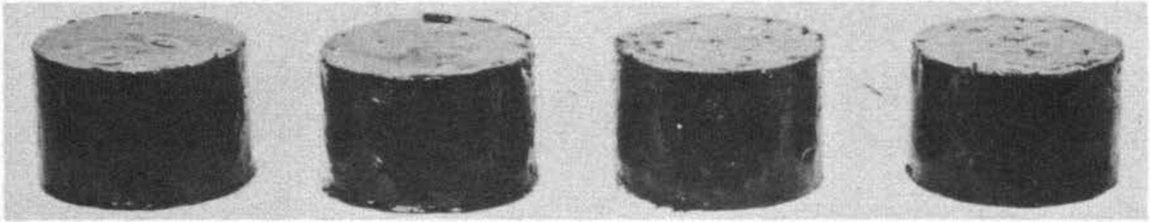
ASPHALT CEMENTS



100-0 % 80-20 % 70-30 % 50-50 % 2 % 4 %

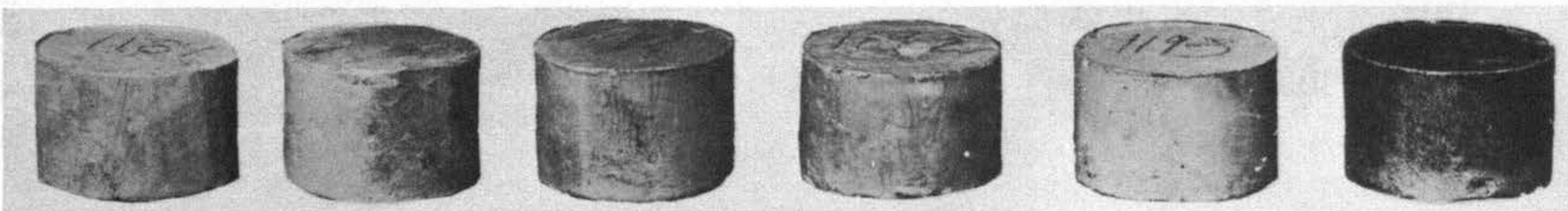
ASPHALTIC LIMESTONE-SAND MIXES LINCOLNITE

BITUMINOUS PAVEMENTS AFTER 10 CYCLES IN LUBRICATING OIL



RT-8 RT-9 RT-10 RT-12

CONTROL JENNITE SOLAC CORDO PERMAKOTE

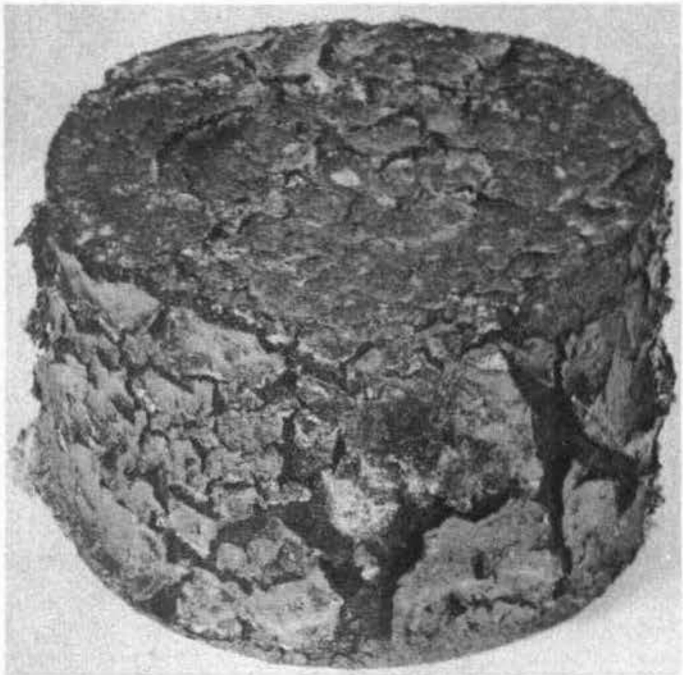


1189 1190 1191 1192 1193 1211

PAINTS (FOR IDENTIFICATION SEE TABLE NO. 1)

PHOTOGRAPH 3

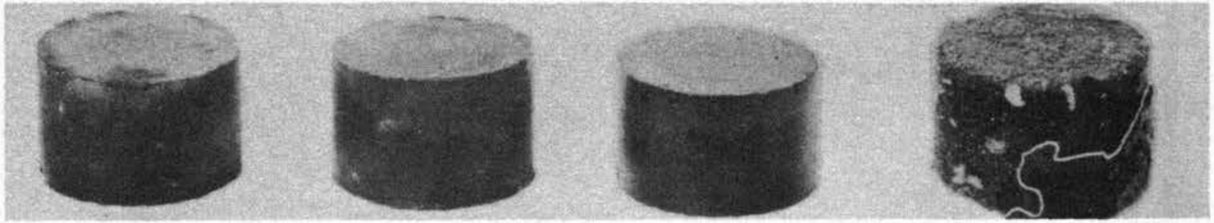
COATED SPECIMENS BEFORE TESTS



SYHM COATING PEELING AFTER DRYING

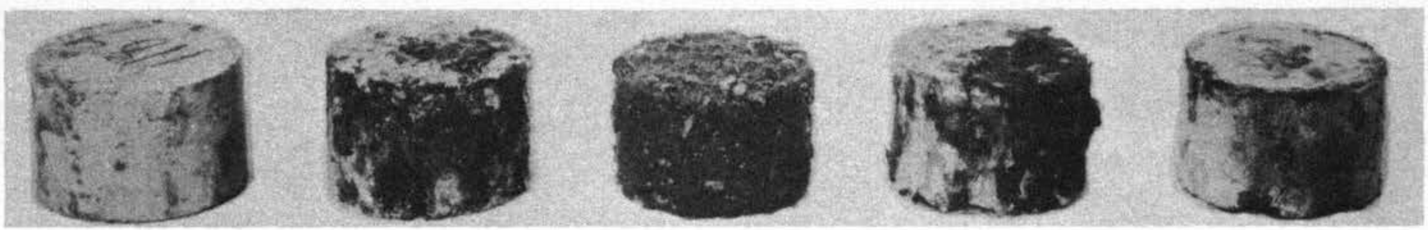
HOLE LEACHED BY GASOLINE IN UNPROTECTED
AREA OF TAR COATED SPECIMEN

PHOTOGRAPH 4



JENNITE SOLAC CORDO PERMAKOTE

PAINT 1211 RT-8 RT-9 RT-10 RT-12



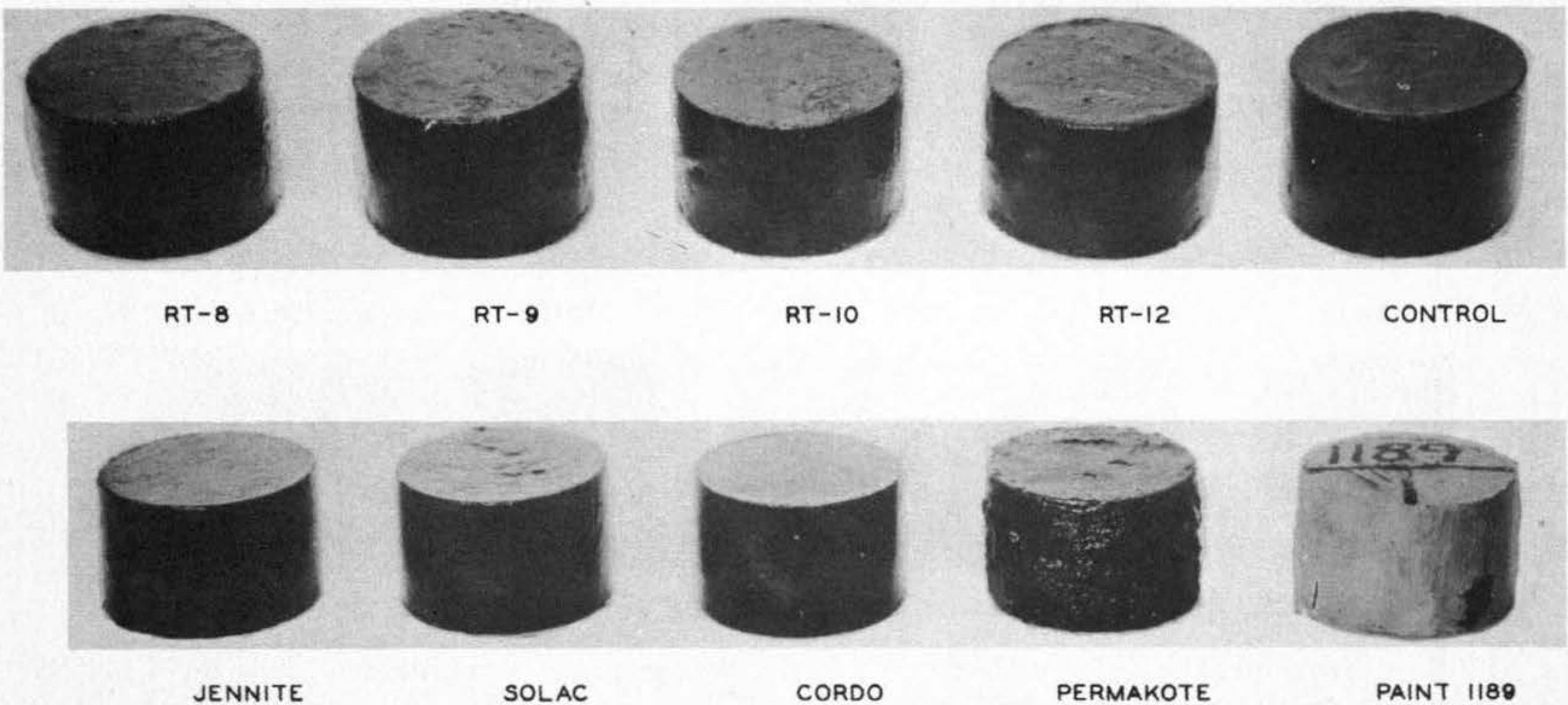
1189 1190 1191 1192 1193

PAINTS (FOR IDENTIFICATION SEE TABLE NO. 1)

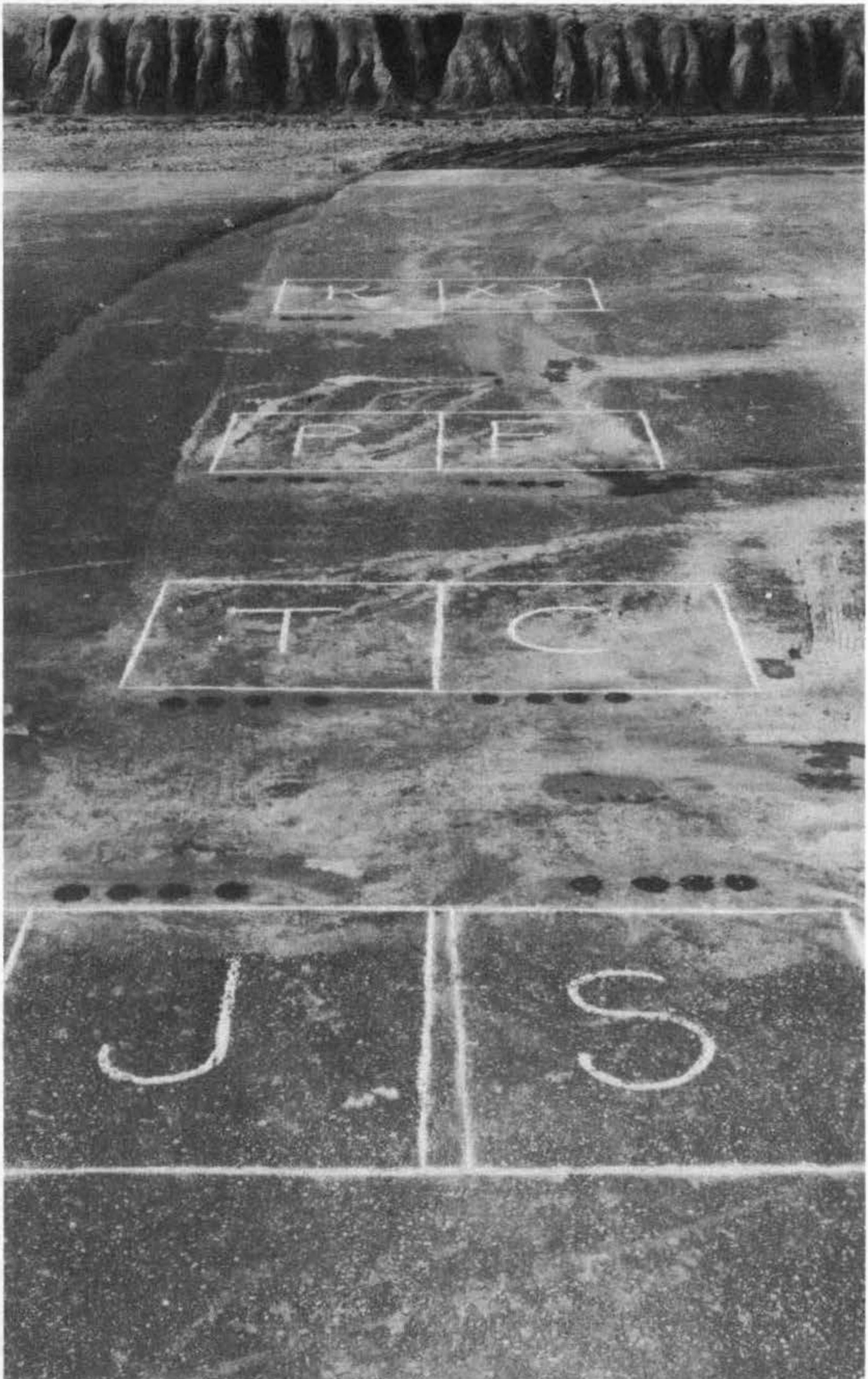
PHOTOGRAPH 5

COATED SPECIMENS AFTER 10 CYCLES IN KEROSENE

PHOTOGRAPH 6



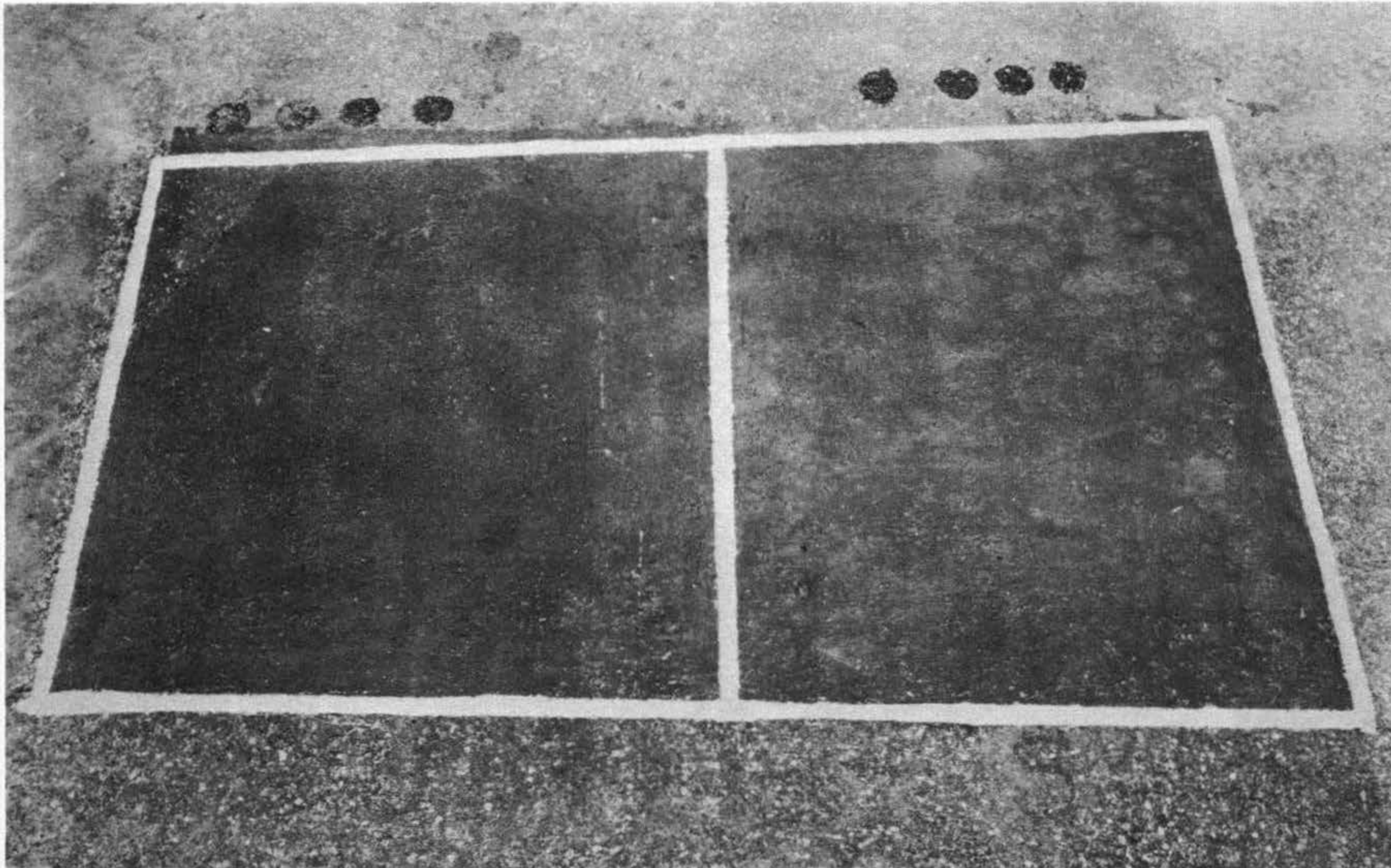
COATED SPECIMENS AFTER 10 CYCLES IN LUBRICATING OIL



GENERAL VIEW OF AREA SELECTED FOR TESTING SURFACING MATERIALS

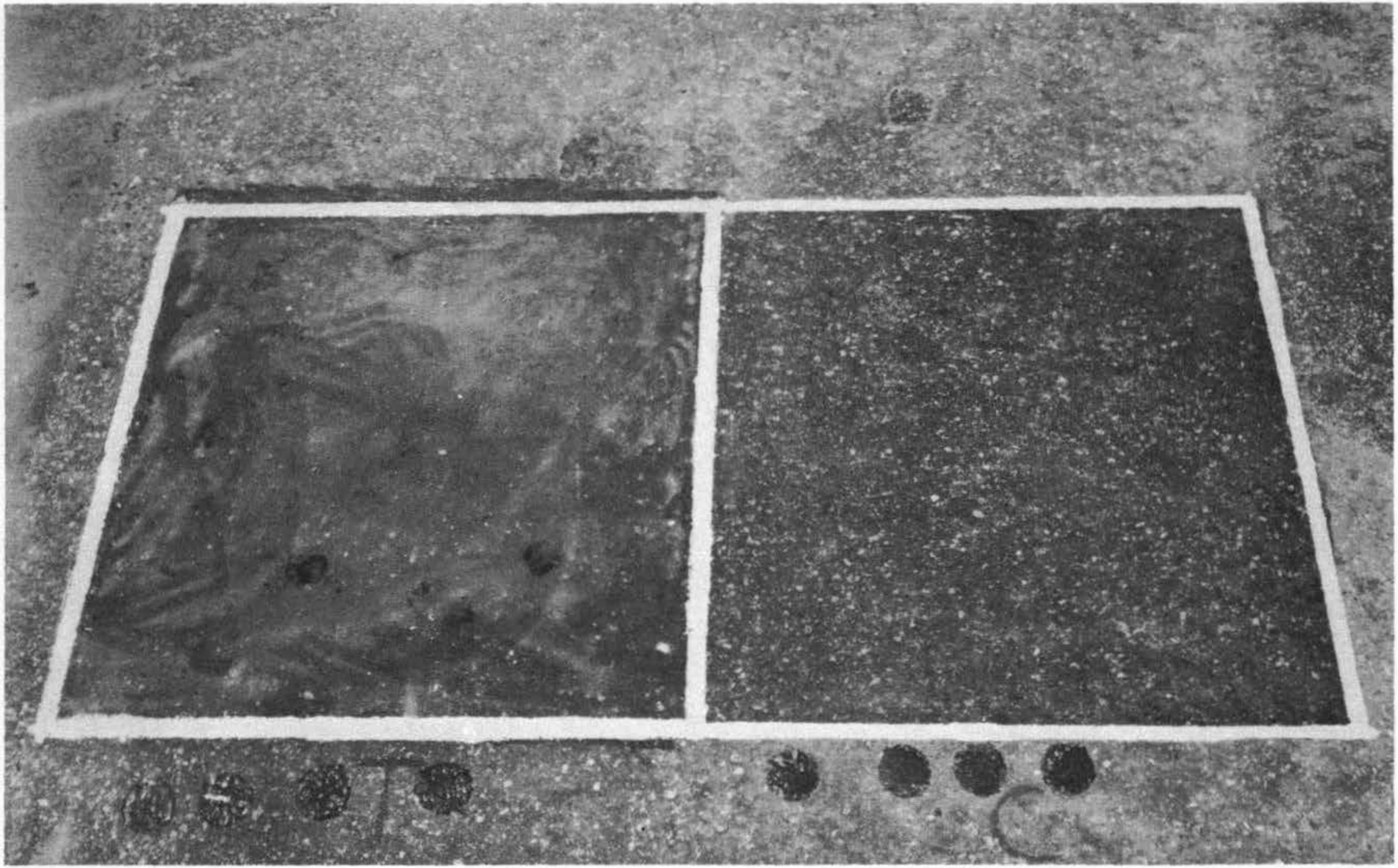
PHOTOGRAPH 7

PHOTOGRAPH 8



JENNITE SOLAC

KEROSENE SATURATED TEST AREAS BEFORE TESTS

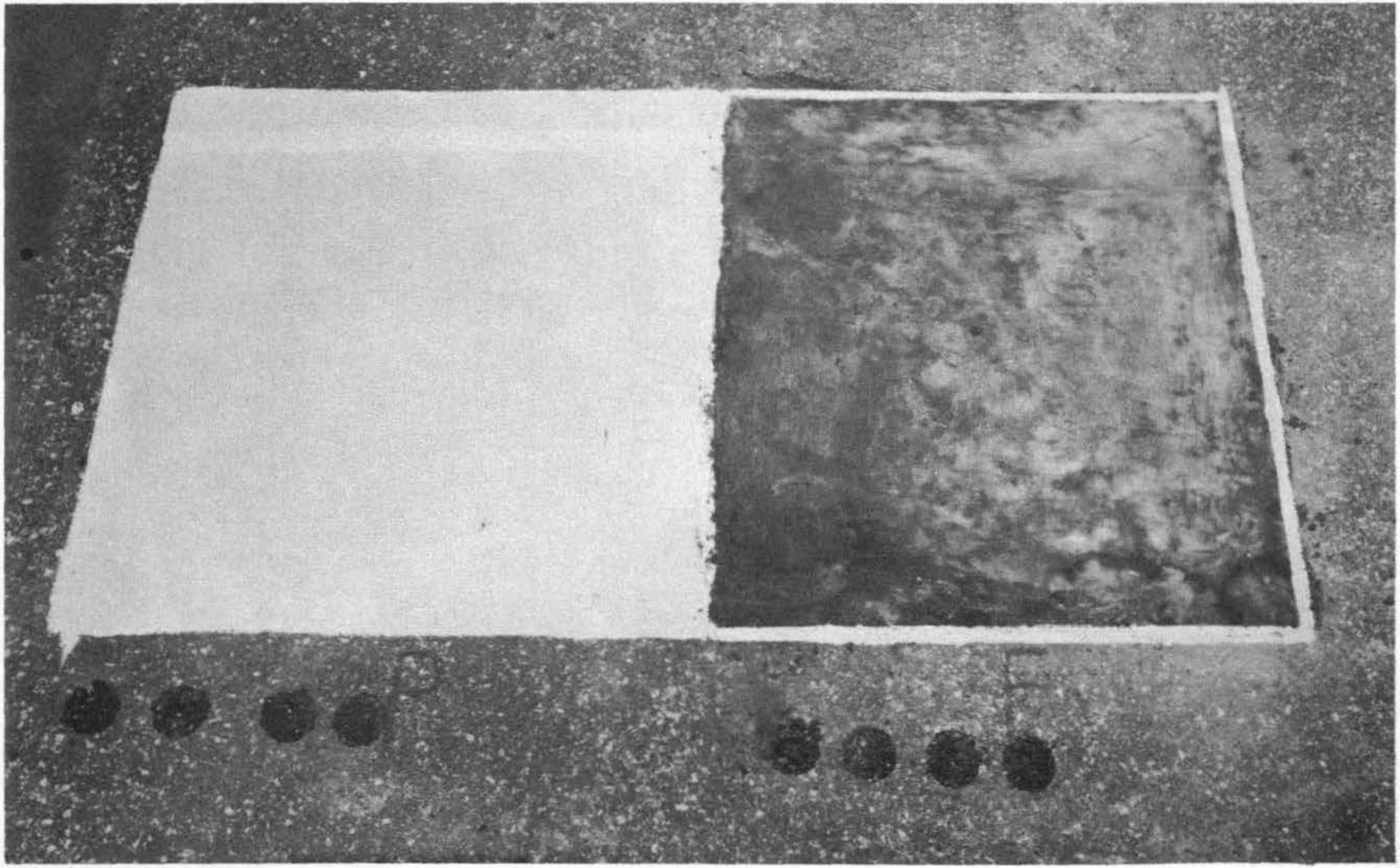


PHOTOGRAPH 9

TAR SEAL CORDO 3M-219 #1

KEROSENE SATURATED TEST AREAS BEFORE TESTS

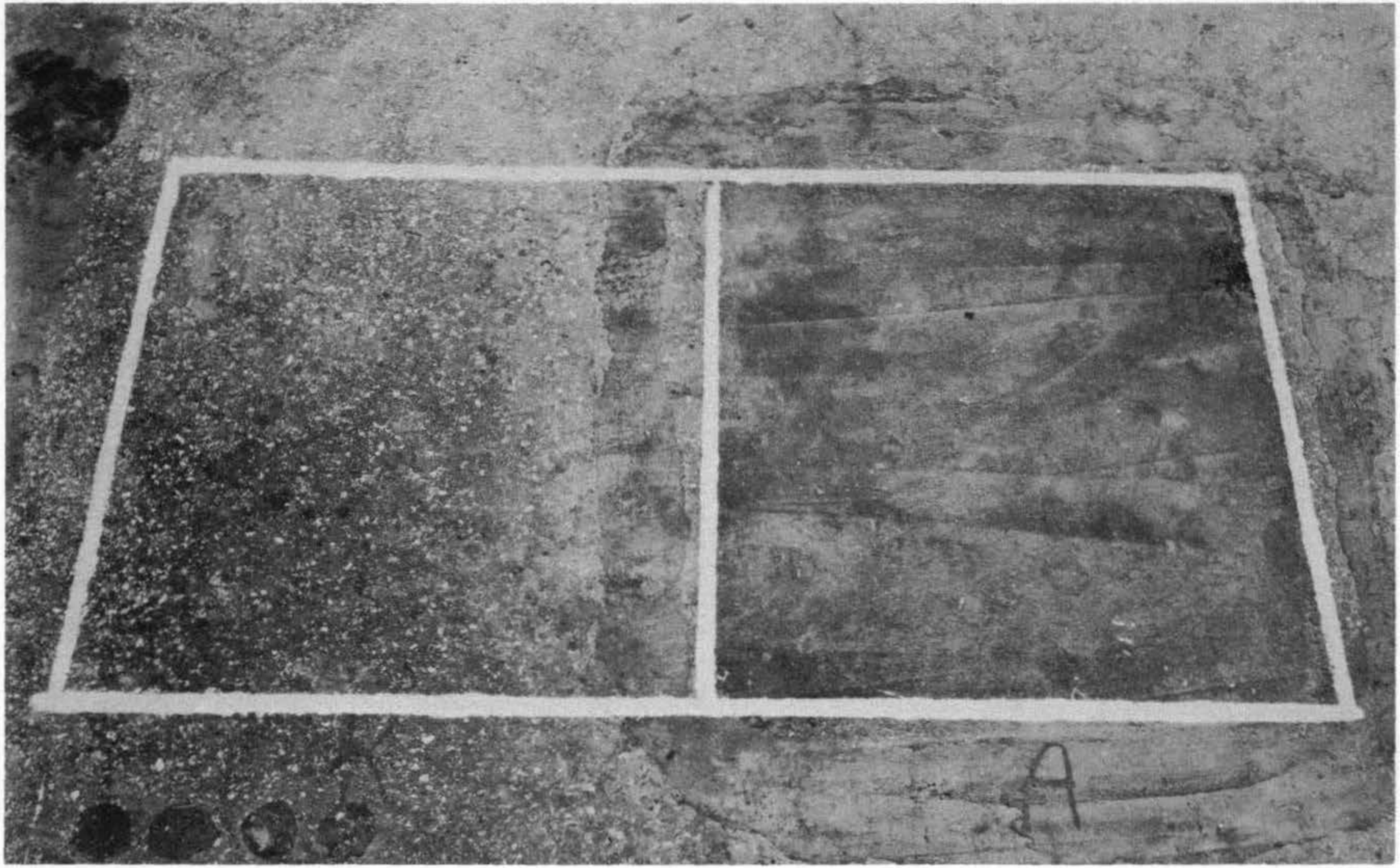
PHOTOGRAPH 10



PAINT # 1189 PERMAKOTE SURFACER

KEROSENE SATURATED TEST AREAS BEFORE TESTS

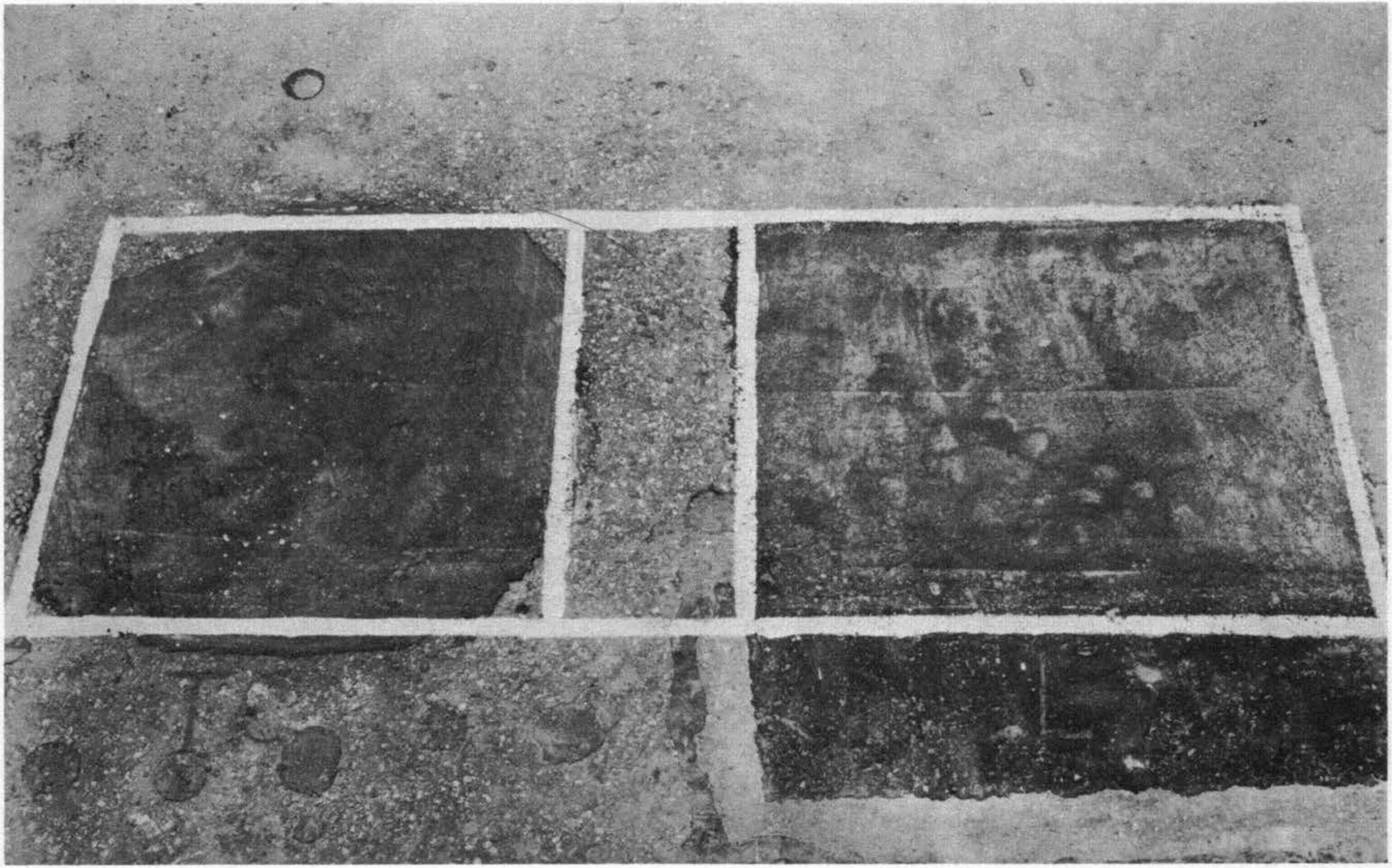
PHOTOGRAPH 11



CONTROL ASPHALTIC LIMESTONE CONCRETE

KEROSENE SATURATED TEST AREAS BEFORE TESTS

PHOTOGRAPH 12



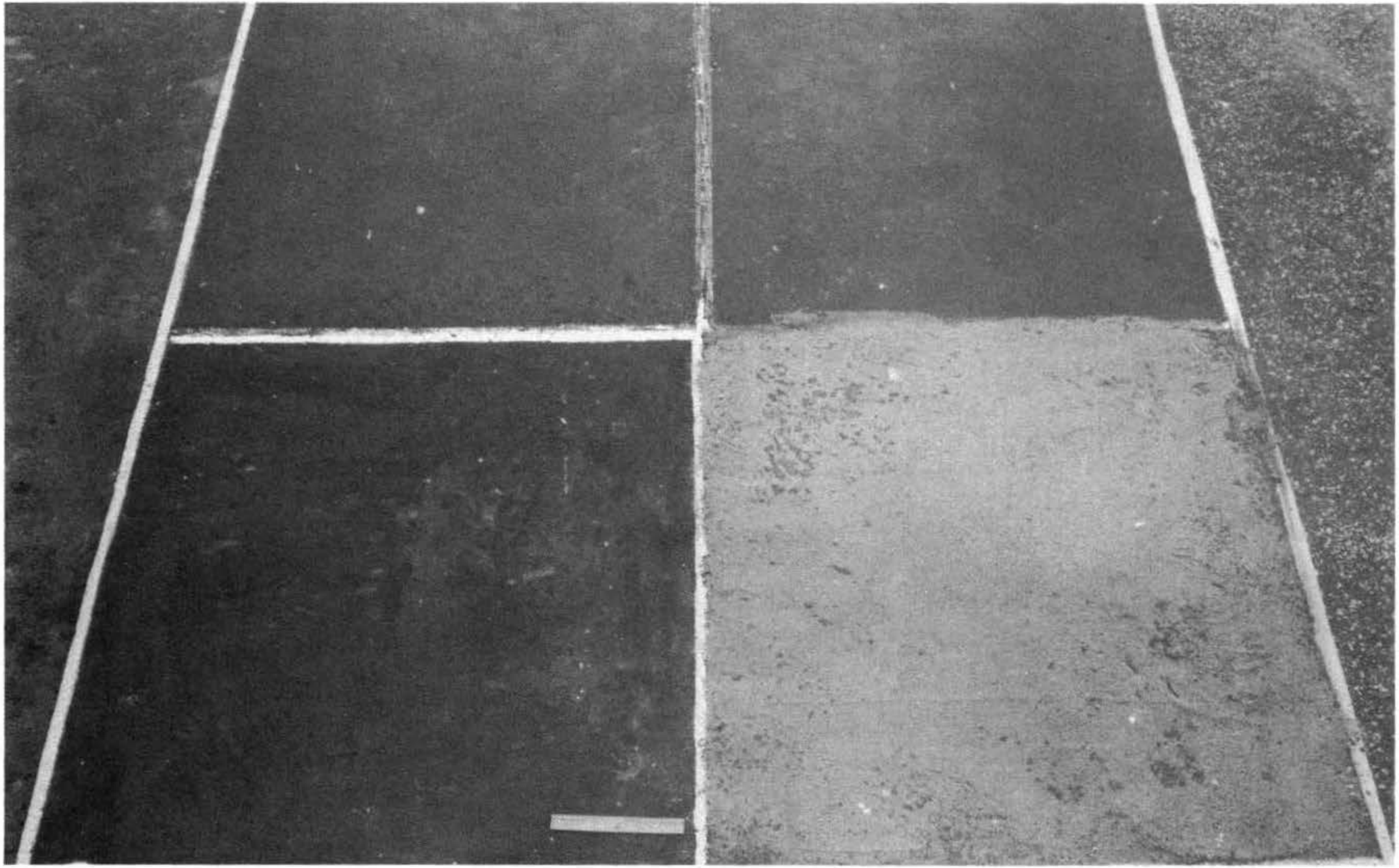
TAR CONCRETE ASPHALTIC CONCRETE WITH 4 % LINCOLNITE

KEROSENE SATURATED TEST AREAS BEFORE TESTS

PHOTOGRAPH 13

TOURNAPULL IN TESTING POSITION

PHOTOGRAPH 14

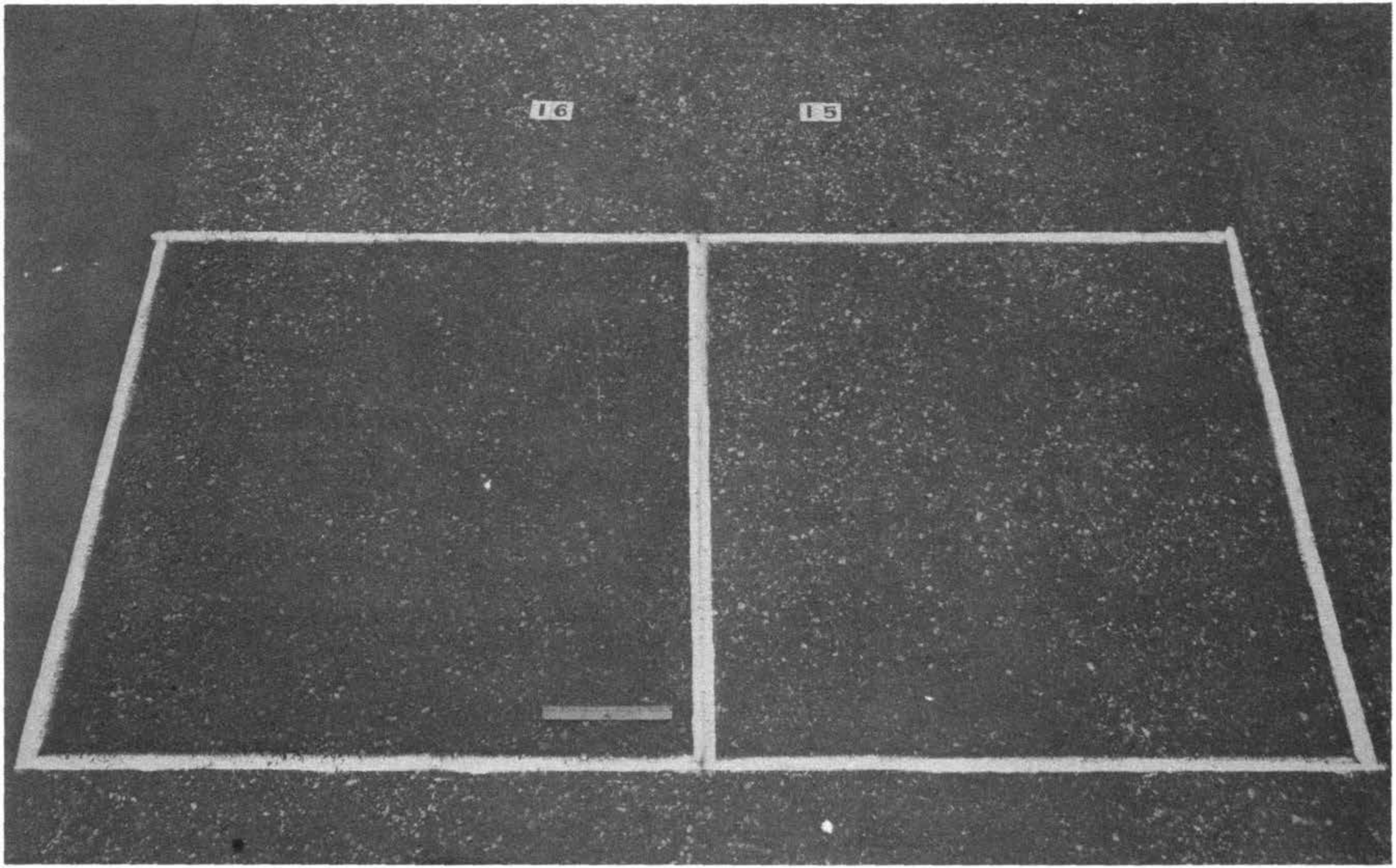


JENNITE
PERMAKOTE SURFACER

SOLAC
TAR SEAL

CONTROL TEST AREAS WITHOUT SOLVENT BEFORE TESTS

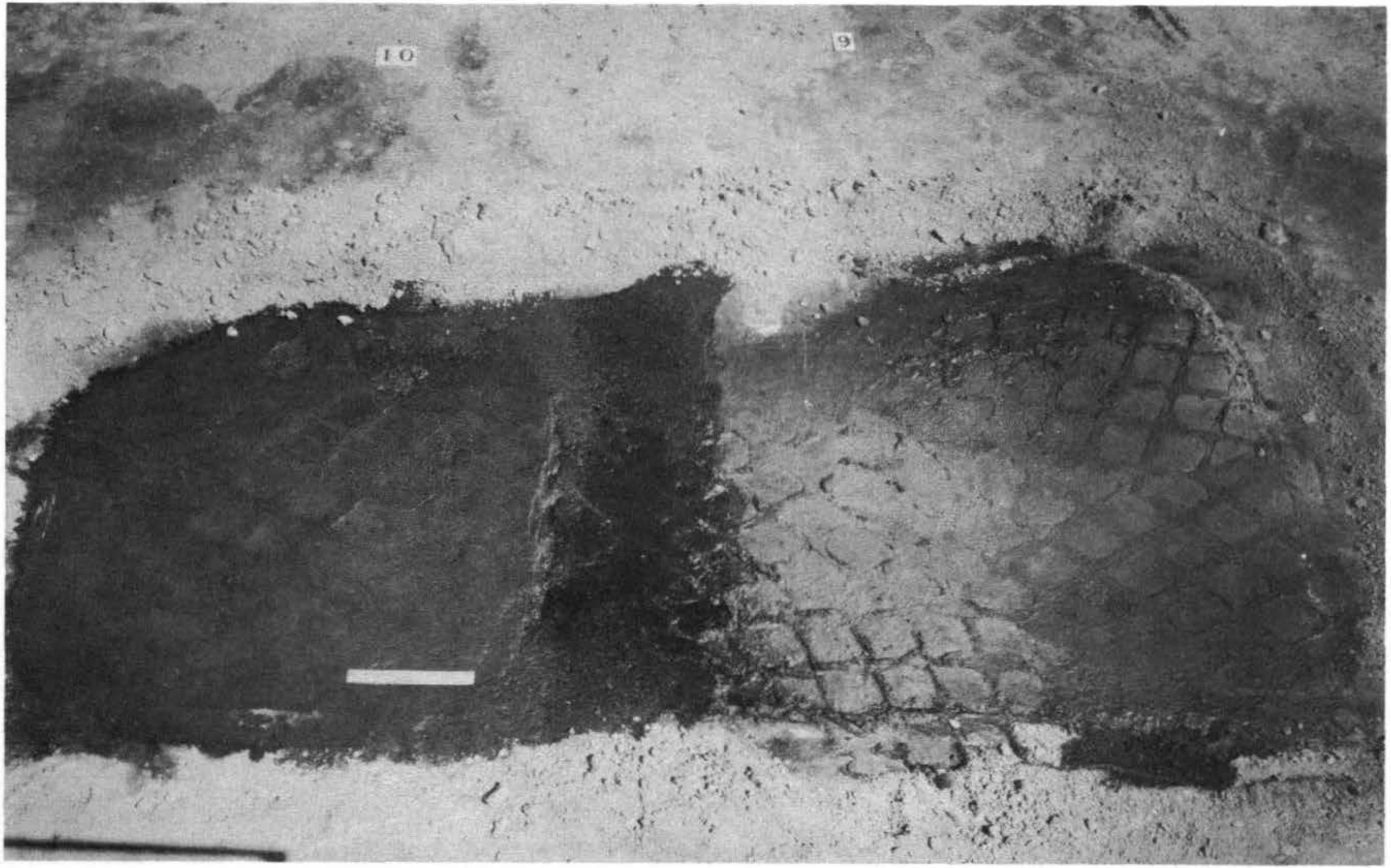
PHOTOGRAPH 15



CORDO 3M-219 # 1 | UNCOATED AREA

CONTROL TEST AREAS WITHOUT SOLVENT BEFORE TESTS

PHOTOGRAPH 16



TAR CONCRETE

ASPHALTIC CONCRETE WITH 4 % LINCOLNITE

KEROSENE SATURATED TEST AREAS AFTER 5 CYCLES

PHOTOGRAPH 17

TAR CONCRETE ASPHALTIC CONCRETE WITH 4 % LINCOLNITE

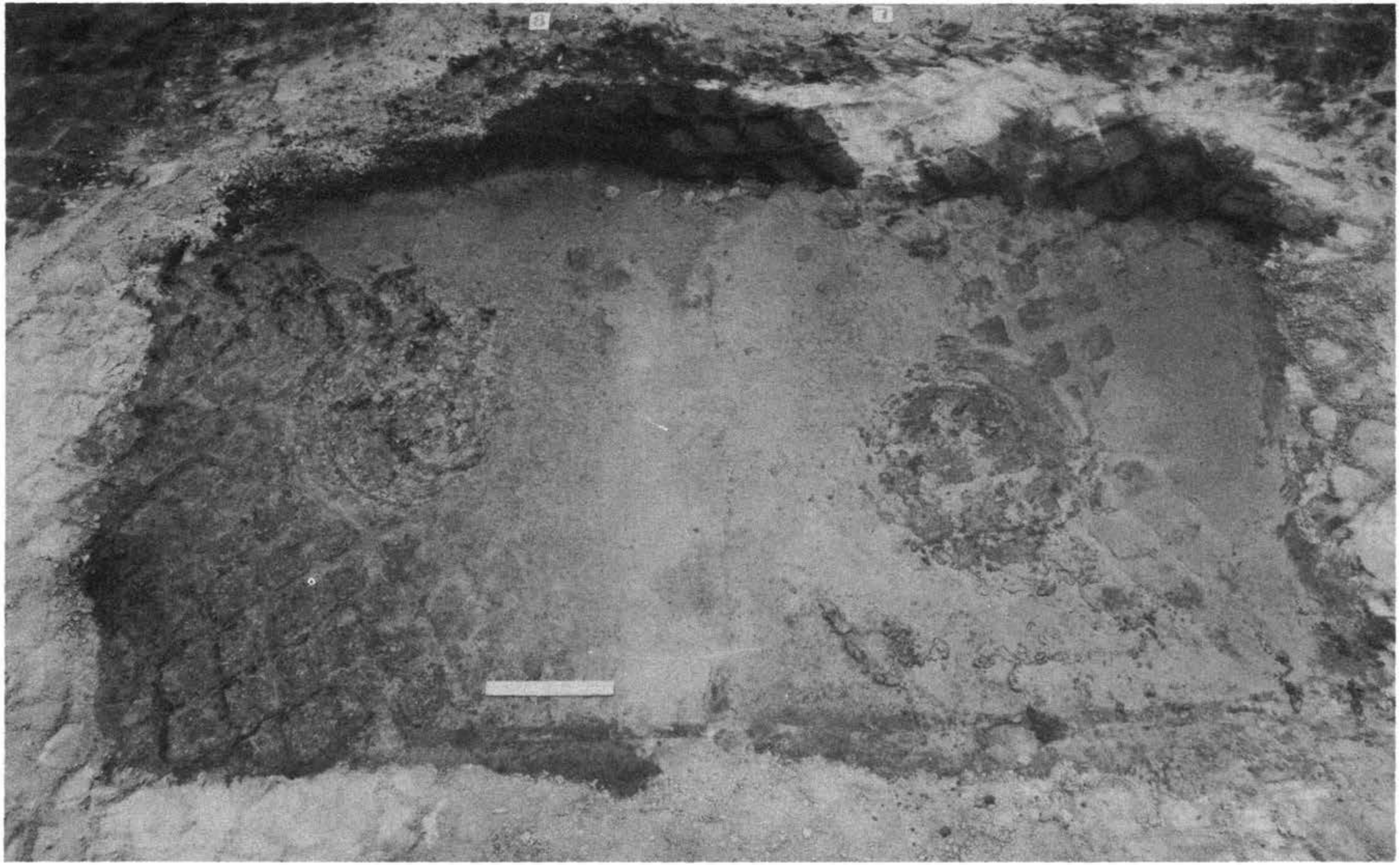
KEROSENE SATURATED TEST AREAS AFTER 10 CYCLES

PHOTOGRAPH 18

CONTROL ASPHALTIC LIMESTONE CONCRETE

KEROSENE SATURATED TEST AREAS AFTER 5 CYCLES

PHOTOGRAPH 19

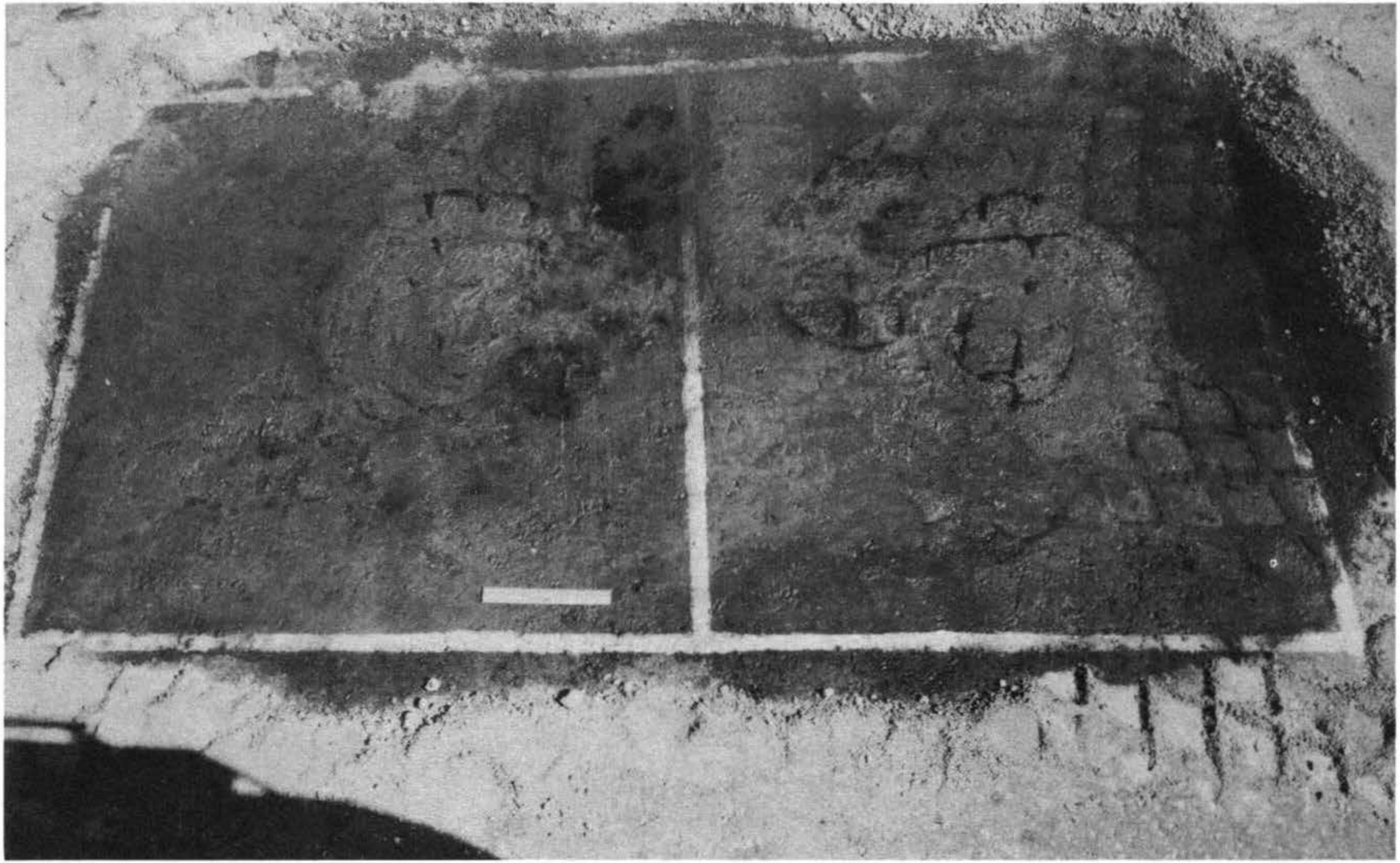


CONTROL

ASPHALTIC LIMESTONE CONCRETE

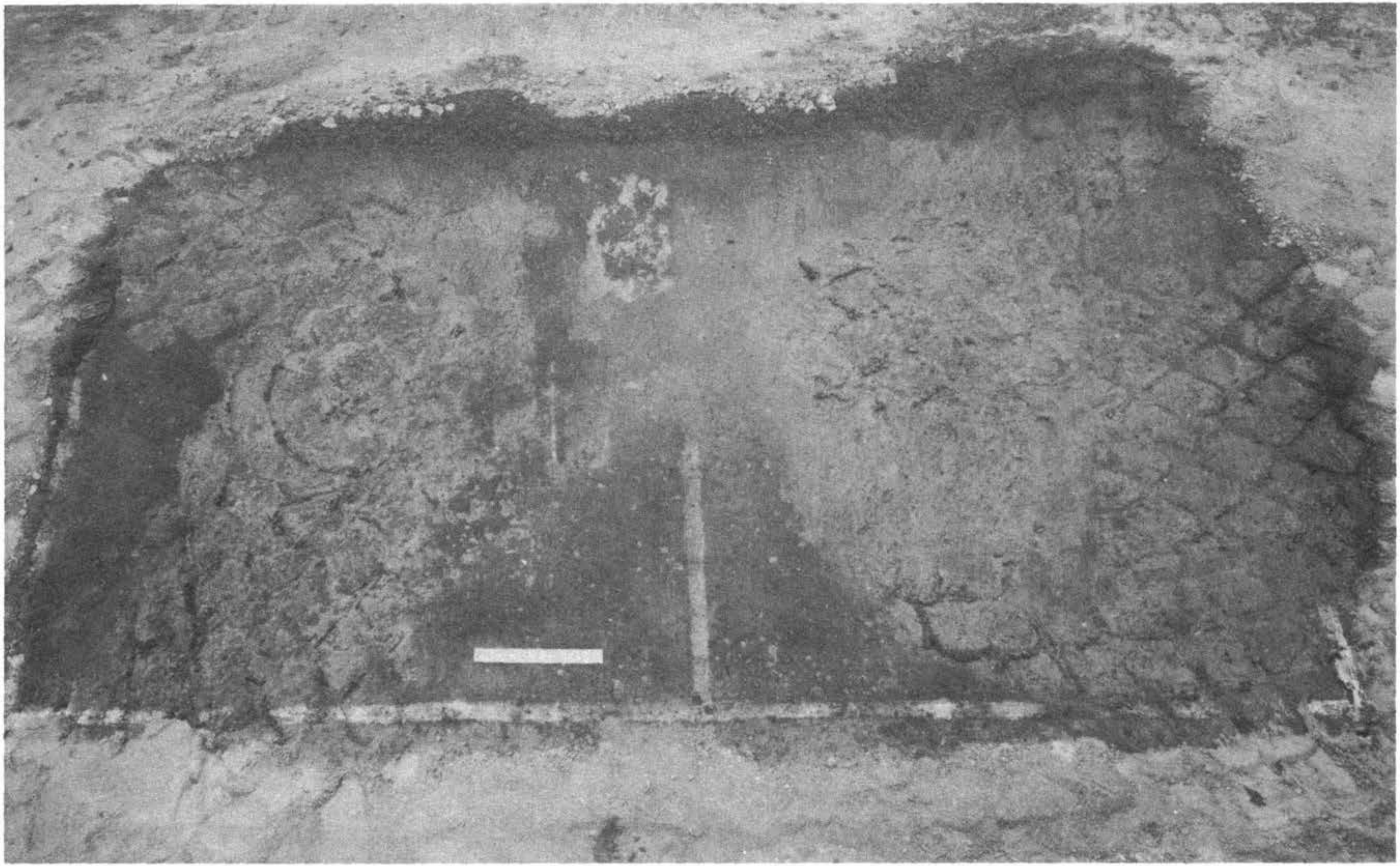
KEROSENE SATURATED TEST AREAS AFTER 10 CYCLES

PHOTOGRAPH 20



JENNITE SOLAC

KEROSENE SATURATED TEST AREAS AFTER 5 CYCLES

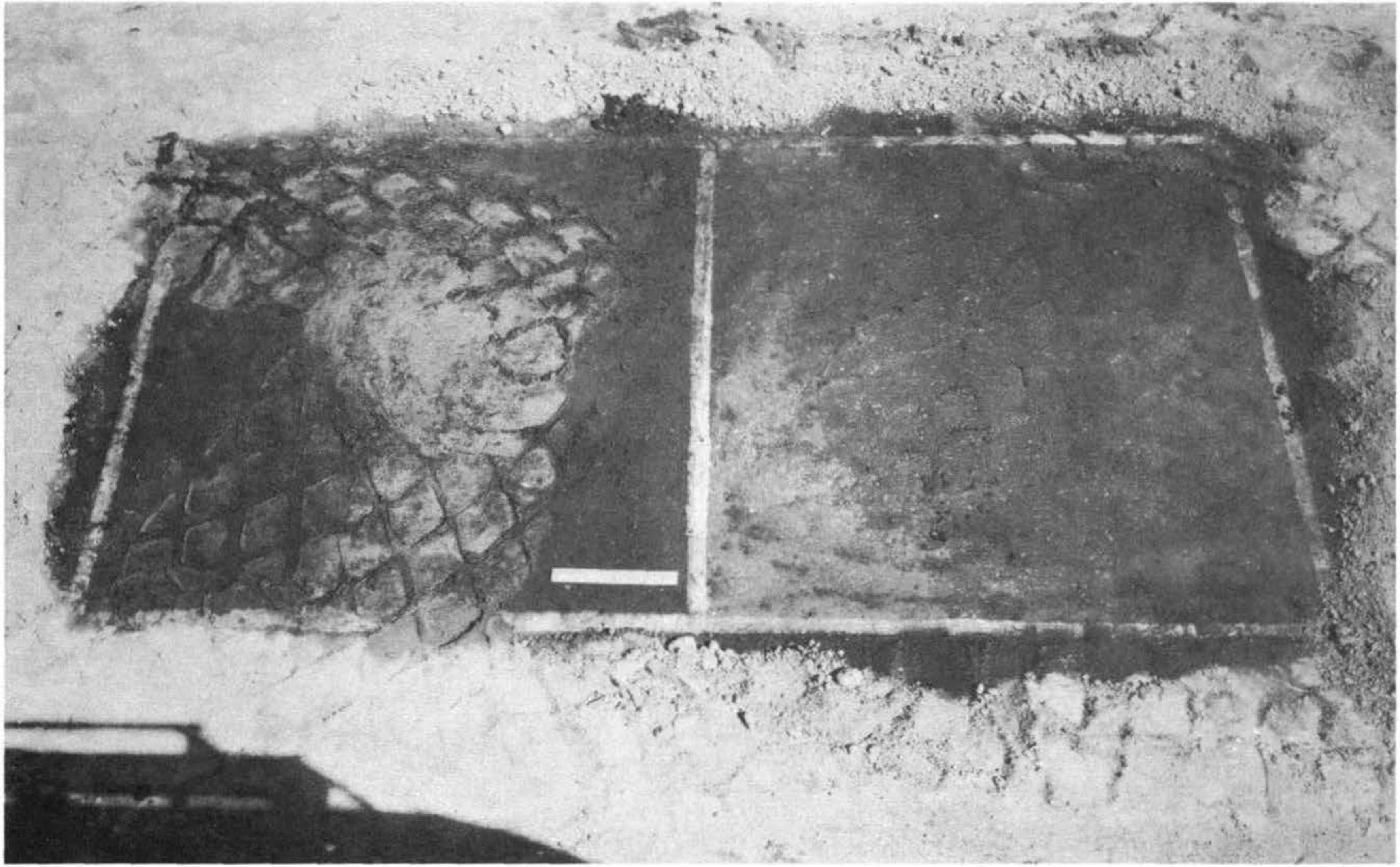


JENNITE SOLAC

KEROSENE SATURATED TEST AREAS AFTER 10 CYCLES

PHOTOGRAPH 21

PHOTOGRAPH 22



TAR SEAL CORDO 3M-219 #1

KEROSENE SATURATED TEST AREAS AFTER 5 CYCLES

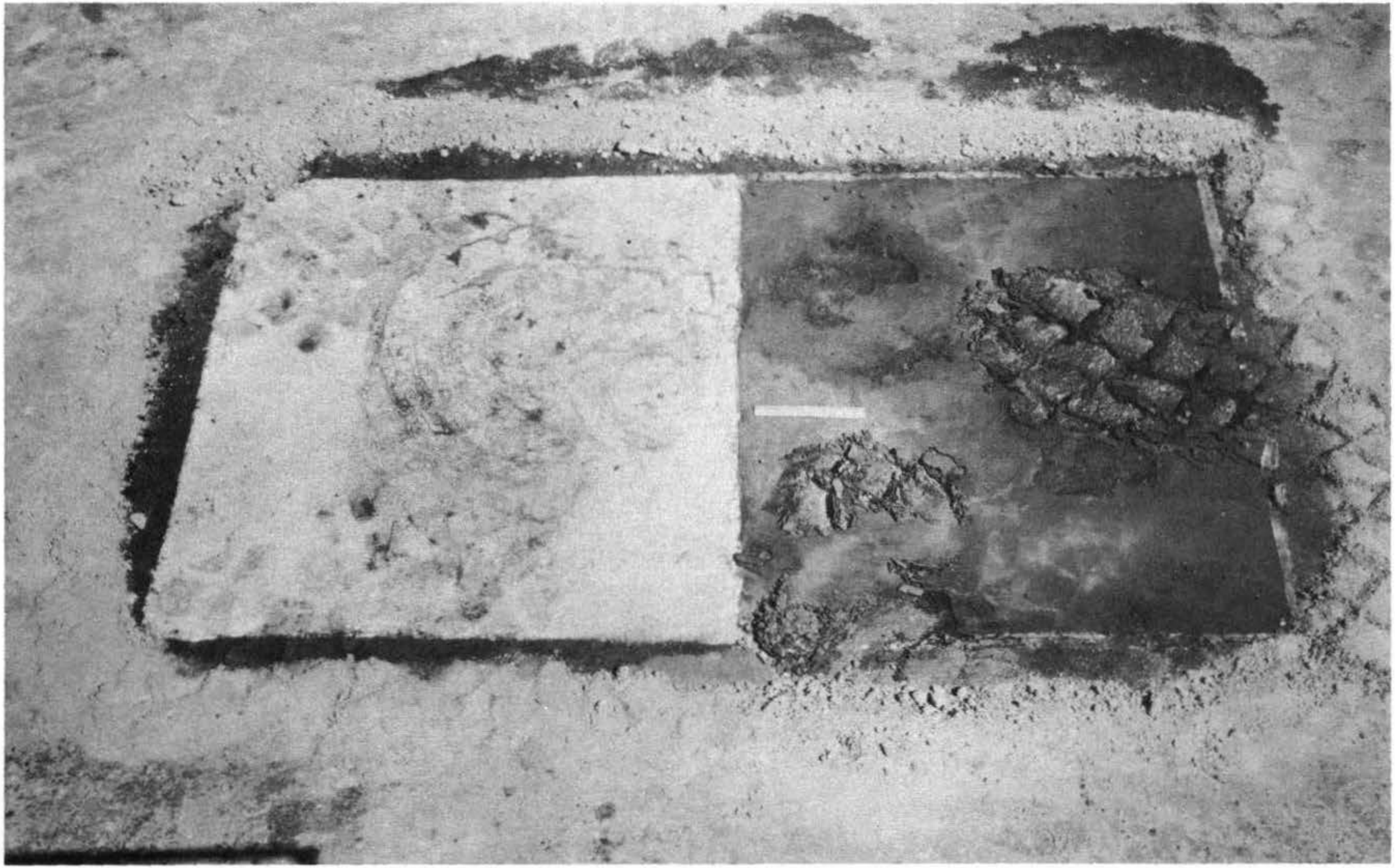
PHOTOGRAPH 23

TAR SEAL

CORDO 3M-219 #1

KEROSENE SATURATED TEST AREAS AFTER 10 CYCLES

PHOTOGRAPH 24



PAINT # 1189 PERMAKOTE SURFACER

KEROSENE SATURATED TEST AREAS AFTER 5 CYCLES

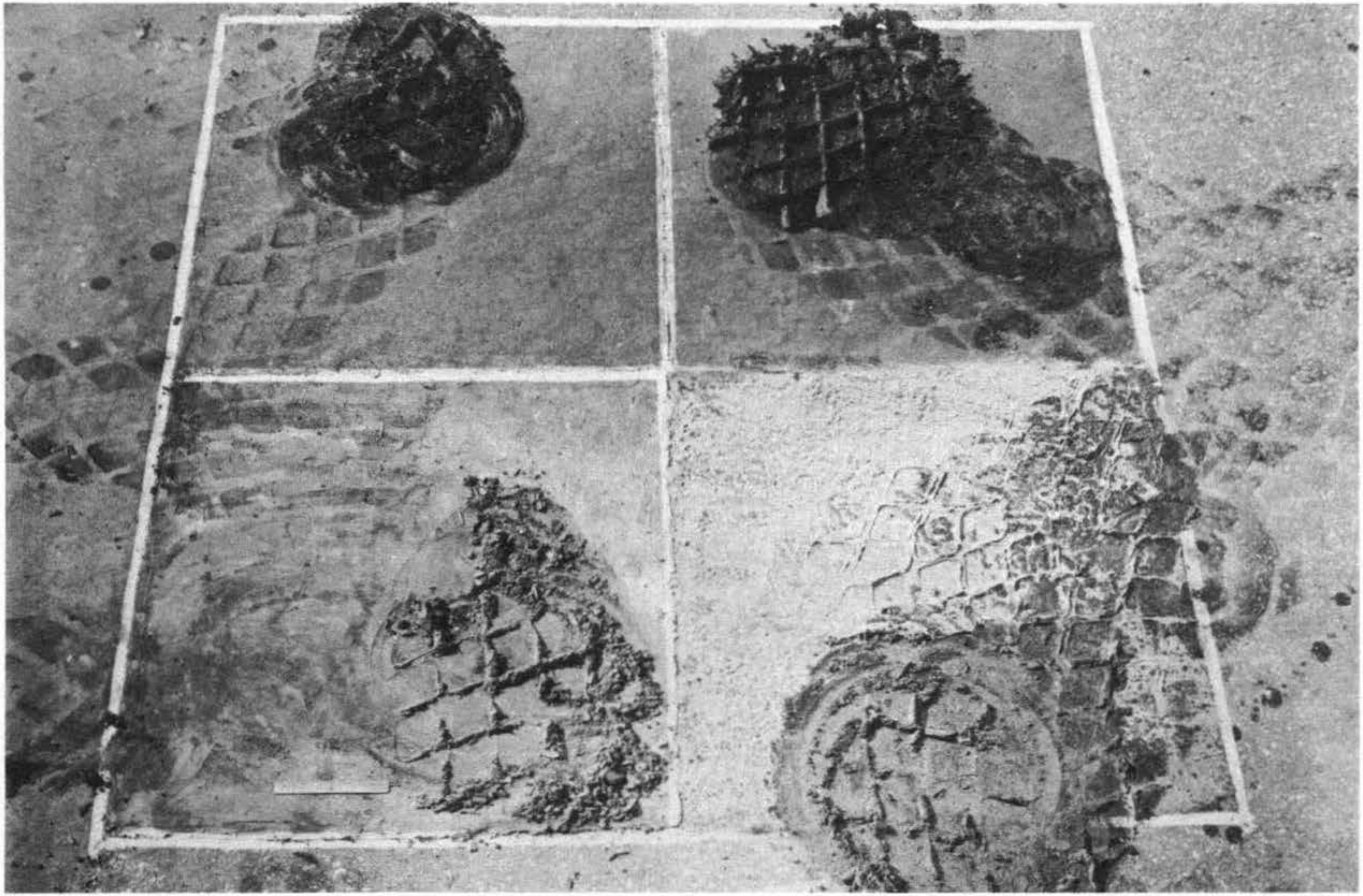
PHOTOGRAPH 25

PAINT # 1189 AFTER 10 CYCLES

PERMAKOTE SURFACER AFTER 5 CYCLES

KEROSENE SATURATED TEST AREAS

PHOTOGRAPH 26

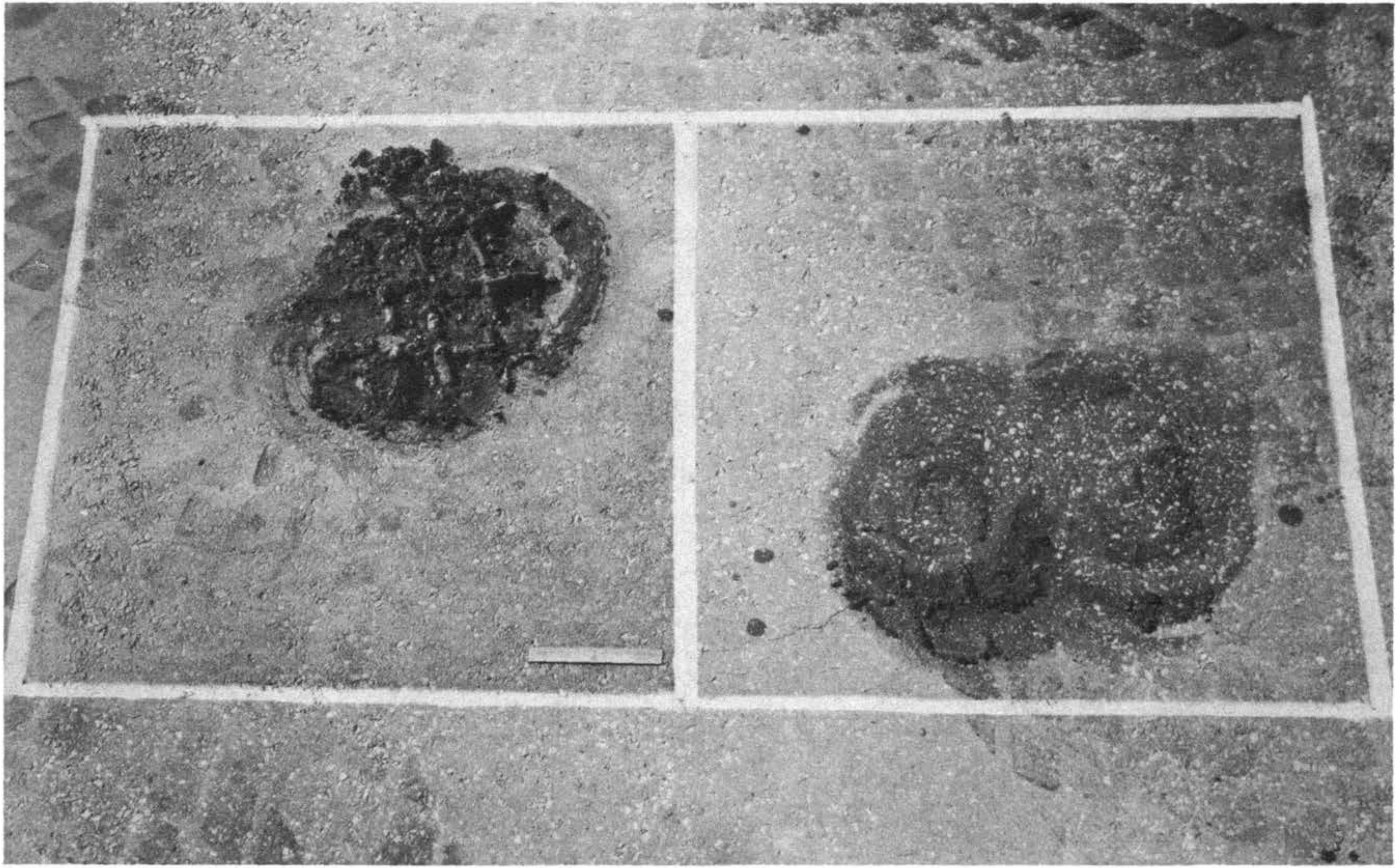


JENNITE
PERMAKOTE SURFACER

SOLAC
TAR SEAL

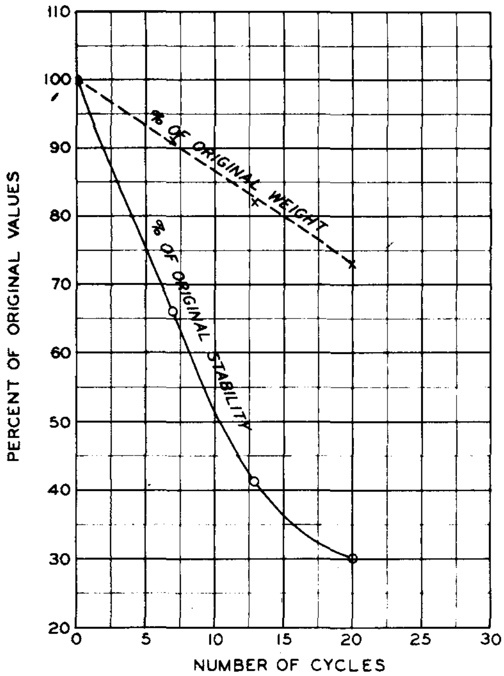
CONTROL TEST AREAS WITHOUT SOLVENT AFTER 5 TURNS

PHOTOGRAPH 27



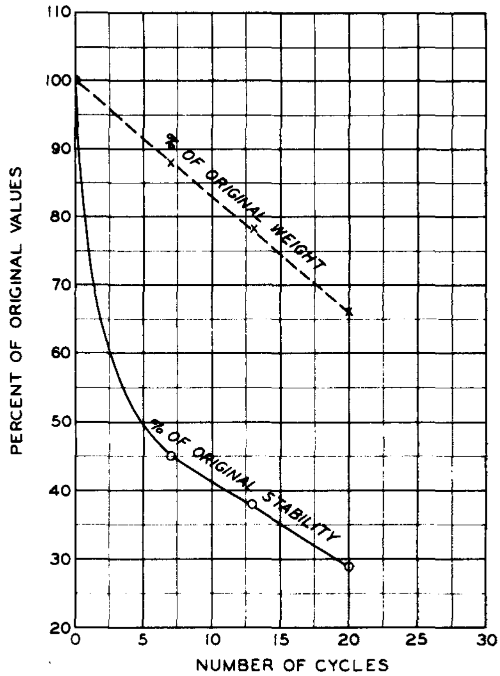
CORDO 3M-219 #1 UNCOATED AREA

CONTROL TEST AREAS WITHOUT SOLVENT AFTER 5 TURNS



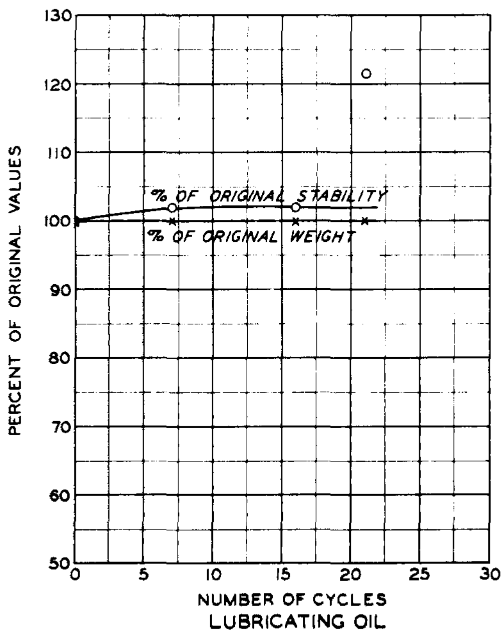
GASOLINE

FIG 1



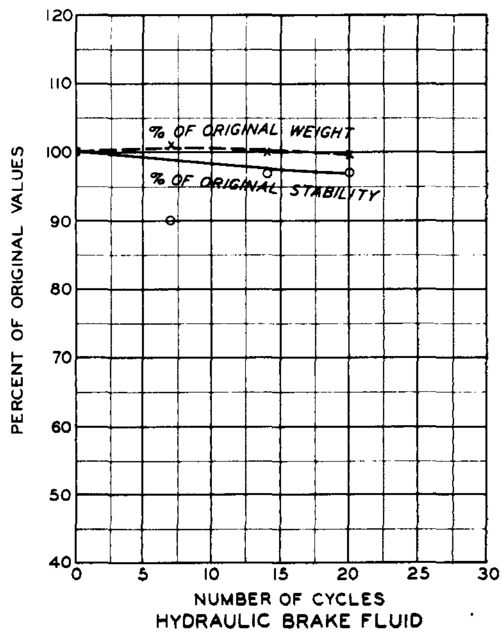
KEROSENE

FIG 2



LUBRICATING OIL

FIG 3



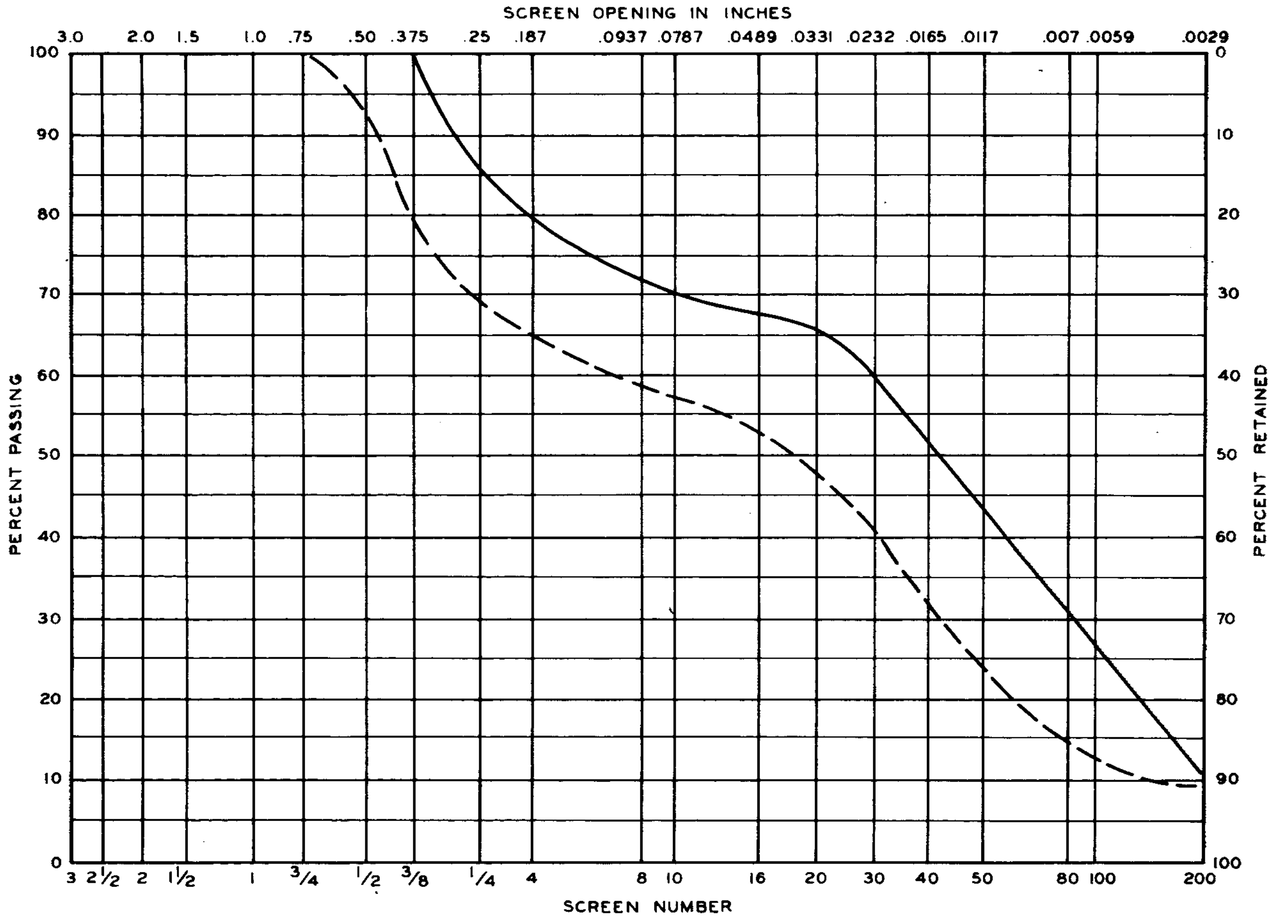
HYDRAULIC BRAKE FLUID

FIG 4

SOLVENT RESISTANT TREATMENTS
FOR BITUMINOUS PAVEMENTS

EFFECT OF VARIOUS SOLVENTS ON ASPHALTIC CONCRETE

PRELIMINARY TEST



LEGEND

LABORATORY SPECIMENS, BITUMINOUS MIXTURES IN FIELD TESTS

EXISTING PAVEMENT USED WITH SURFACING MATERIALS IN FIELD TESTS

SOLVENT RESISTANT TREATMENT FOR BITUMINOUS PAVEMENTS

AGGREGATE GRADING CHART

PLATE 2